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ROYAL AIR FORCE.

FIELD SERVICE POCKET BOOK

Promulgated for the information and guidance of all concerned.

By Command of the Air Council.

W. Nicholson

AIR MINISTRY,
December, 1924.

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NOTE.

This book is intended as a handy book of reference for use on Active Service or Manœuvres when other books are not available.

It should not be quoted as an authority in Official correspondence, nor should it be utilised as a text book for study.

In the present state of the Royal Air Force changes are rapid. Officers should keep the book up to date by amending it, in accordance with any changes which may appear in Official publications, and amendments or additions issued.

Suggested additions or corrections should be forwarded through the usual channels to the Secretary, Air Ministry.

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ROYAL AIR FORCE FIELD SERVICE POCKET BOOK.

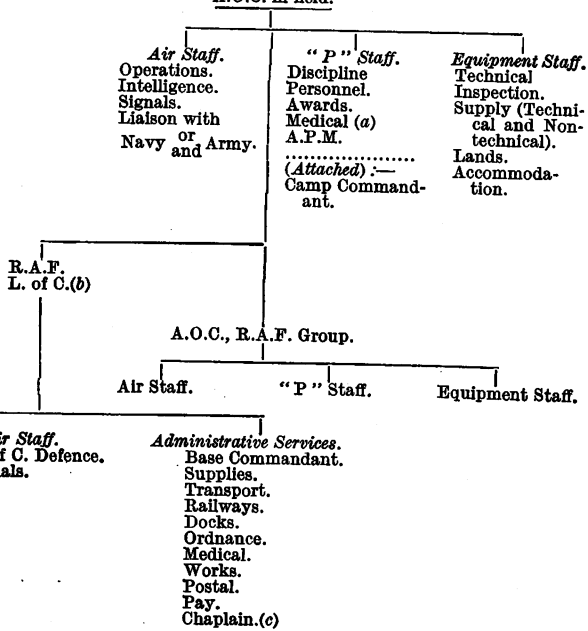
Chapter I.

1. GENERAL ORGANISATION AND FUNCTIONS OF THE STAFF.

1. The staff of an Air Force Headquarters is organised in three branches, viz. :—

The Air Staff.
The "P" Staff.
The Equipment Staff.

2. The following table shows the normal organisation of the headquarters of an Air Force operating in the Field :—



Notes.—(*a*) The P.M.O. will deal direct with A.O.C. on matters of policy. He is the channel of communication between "P" staff and the lower formations and units on medical matters, and for the issue of instructions relating to them. He deals directly with Equipment Staff on questions in connection with the siting and construction of hospitals, also questions of hospital trains, hospital ships and dieting in hospitals.

(*b*) In combined operations these services are maintained by the Army.

(*c*) Attached to "P" Staff of A.O.C.

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3. For the efficient performance of staff duties, all three branches must work in close co-operation.

The Air Staff is responsible that, with due regard to secrecy, information as to the situation and the probable requirements of units is furnished to the other branches of the staff in sufficient time to enable these requirements to be met.

4. The broad outlines of the normal duties of the three branches are as follow:—

(*a*) **The Air Staff** is responsible for co-ordination of staff work; plans for concentration in the theatre of operations; location of all units in the theatre of operations; plans, operations and issue of operation orders; movements by road and air in the theatre of operations; signal communications; war organisation and training of units; organisation of the lines of communication; intelligence, including information as to enemy forces; the selection of sites for aerodromes and landing grounds; censorship; war diaries.

Questions of policy in connection with international and martial law; flags of truce and correspondence with enemy; control over press and press correspondents; secret services; ciphers; care and disposal of captured documents; maps; preparation of reports and despatches relating to above duties.

(*b*) **The "P" Staff** is responsible for questions relating to discipline; Air Force law; executive duties connected with the posting and promotion of officers; supply of personnel; personal services; pay; promotion, honours and rewards; leave; spiritual welfare; casualties; medical and sanitary services; disposal of prisoners of war; burying parties and places; ceremonial; postal services; administration of martial law and compilation of regulations relating thereto; police measures; issue of routine orders and instructions, and the preparation of reports, despatches and diaries relating to the above duties.

(*c*) **The Equipment Staff** is responsible for technical supervision of equipment, arrangements for embarkation and landings, if in a friendly country, subject to general control of the air staff; distribution in detail of quarters and buildings within the areas delimited by the air staff; movements, except by road and air in the theatre of operations; arrangements for rail, inland water and sea transport; provision and distribution of all equipment, stores and supplies, including stationery; fire services; rendering of accounts for expenditure of an abnormal character; the co-ordination of all administrative arrangements on the L. of C., subject to strategical and technical considerations, the limitations of which are communicated by the air staff; issue of routine orders and instructions and the preparation of reports, despatches and diaries relating to the above duties.

5. When the R.A.F. is acting under the orders of a military commander-in-chief, the above distribution of duties will apply in general, but may be modified when any of the services specified are carried out by the Army for the R.A.F.

6. When operating with the Navy, the R.A.F. will either be—

(*a*) Embarked in H.M. ships.
(*b*) Operating from permanent land bases at home or abroad; or
(*c*) Landed overseas and operating from the coast.

In the case of (*a*), a senior R.A.F. officer, together with the necessary staff officers, will be attached to the staff of the naval C.-in-C.

In the case of (*b*), the senior R.A.F. officer commanding the Naval air force units on shore will work directly under the orders of the naval C.-in-C. In addition the latter officer will be allotted a R.A.F. officer for liaison duties, who will be attached to his staff to advise on air matters.

In the case of (*c*), the organization and functions of the staff considered necessary for the operations will be generally as laid down in paras. 2 and 5 above.

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2. ORDERS.

General Rules Regarding the Preparation and Despatch of Orders, Reports and Messages.

1. Communications in the field may be verbal or written, according to circumstances. The following general rules should be observed:—

(*a*) Orders issued by the higher commanders and reports will normally be prepared in writing. When issued verbally their substance should be recorded in writing both by the issuer and the recipient, or his staff officer, whenever it is practicable to do so. A record of all reports will be kept in the unit record book.

(*b*) Orders and reports must be as concise as is possible with due regard to clearness. They must be precise as regards time and place, the language should be simple and the handwriting easily legible. Anything of an indefinite or conditional nature such as "dawn," "dusk," "if possible," "should," is to be avoided.

(*c*) The continental system of time will be adopted in all correspondence, orders, despatches, and messages. The time of origin, that is, the time at which the order, etc., is signed by the originator, will always be represented by four figures, the first two figures 00 to 23 representing the hours from midnight to midnight, the second two figures representing the minute of the hour; for example:—

12.10 a.m.	will be	written	0010.
3.25 a.m.	,,	,,	0325.
noon	,,	,,	1200.
3.25 p.m.	,,	,,	1525.
11.40 p.m.	,,	,,	2340.

The symbols "0000" and "2400" will not be used, but the order, etc., will be timed 2359 or 0001.

(*d*) Names of places or persons will be written in block letters, *e.g.*, LONDON or WELLINGTON. Names of places must be spelt exactly as on the map in use. Only abbreviations about which there can be no doubt will be used.

(*e*) In naming units or formations from which a portion is excluded, the unit will be named and the words "less .....;" appended; *e.g.*, "No. 3 Squadron less one flight."

(*f*) If a map is referred to, the map used must be specified unless this is provided for in standing orders. The position of places will, as a rule, be denoted either by naming the map square, if any, on which they appear, or by the points of the compass, *e.g.*, "wood, 600 yards S.E. of TETSWORTH"; or, when no points of reference are available, by actual compass bearings, *e.g.*, "hill, 1,500 yards true bearing 272° from CHOBHAM CHURCH"; or by description, *e.g.*, "cross roads ½ mile S.W. of the second "E" in HASELEY," the letter indicated being underlined. Abbreviations should not be used to indicate main cardinal points, these should be given in full, *e.g.*, "NORTH." A road is best indicated by the names of places on it, care being taken to name sufficient places to ensure that the road intended is followed. A position, whether occupied by hostile troops or not, will be described from right to left, looking in the direction of the enemy. The terms "right" and "left" are used in describing river banks, it being assumed that the writer is looking down stream. Except in the foregoing case, indefinite or ambiguous terms, such as right, left, before, behind, front, on this side of, &c., must not be used, unless it is made clear to what force they refer.

(*g*) When bearings are given, they will invariably be true bearings, and this should be so stated. The variation of compasses must be checked before use.

(*h*) The writer, having finished his report or order, should read it through carefully at least once, and, if possible, get someone else to read it, in order to assure himself that it is clear, and, in the case of

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an order, that it is calculated to influence the recipient only in the way that it is intended.

(*i*) An order or report must be clearly signed, the rank of the sender, his appointment, and the force with which he is serving being stated.

(*j*) A copy of all orders and messages sent will be kept by the sender, the copy and original being endorsed with the method and hour of issue or transmission, *e.g.*, "dictated to A.Os.C. of 1st and 2nd Groups at 1120 hours," or "by signal to air staff officers 2nd and 3rd Wings at 2230 hours."

(*k*) The place to which reports are to be sent (Reporting Centre) must be clearly stated in orders.

2. Every precaution should be taken to assist the recipient of an order or report in grasping its contents with a minimum of trouble and delay.

3. In reporting on an enemy, accuracy as regards times, places, position, approximate strength, branch of the service, formation and direction of movements of the troops reported on, is of first importance.

It is more important that the information contained in a report should be relevant and accurate, and should arrive in time to be of use, than that the report should be long or elaborate. This applies equally to written or verbal reports and to sketches.

4. A plan or panoramic sketch is a useful adjunct to a report, and it is often possible to dispense with the report and convey all essential information on the sketch or plan. Clearness and relevancy are required, not artistic effect.

A plan or sketch should be drawn roughly to scale, the latter being indicated both by drawing and in words.

Important points, *e.g.*, the width of a road or stream, whether a railway is of double or single line, etc., should be described in words or figures.

5. The authority who despatches a communication is responsible that proper steps are taken to ensure its safe and timely delivery. Important communications should be sent by more than one means, and acknowledgment of receipt should be obtained.

6. Communications of a secret nature should usually be in cipher; but it must be remembered that enciphering and deciphering causes loss of time. A message should not be sent partly in cipher and partly "en clair."

Arrangement of Orders.

7. Orders issued by commanders may be classified as follows:—

(*a*) Standing Orders.
(*b*) Routine Orders.
(*c*) Operation Orders.

Special orders, such as "Orders of the Day," will occasionally be necessary, and special instructions instead of operation orders may be required in the case of detached units.

Each class of order will be prepared and numbered separately. In the case of standing or routine orders, the headings of the order should indicate the class to which it belongs.

Standing Orders.

8. The object of standing orders is—

(1) To adapt existing regulations to local conditions.
(2) To prevent frequent and unnecessary repetitions in operation and routine orders.

Unless carefully revised and kept up to date, standing orders may lead to misunderstanding. For this reason they should be confined to essentials, and additions or deletions promulgated as necessary.

9. The commander issuing standing orders is responsible that any alteration in them is notified to units, and that they are communicated to new units coming under his command.

10. It is important that all officers should be thoroughly conversant with standing orders.

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Routine Orders.

11. The object of routine orders is to disseminate information throughout the units composing a force, and they should deal with all matters not concerned with operations, such as discipline, internal administration, pay, etc.

Routine orders, not being of a confidential nature, may be distributed freely.

Operation Orders.

12. The object of an operation order is to bring about a course of action in accordance with the intentions of the commander, and with full co-operation between all units.

13. Operation orders are prepared and issued by the Air Staff. Operation orders define the object to be attained, but as far as possible leave open the means to be employed.

Instructions are communications to a subordinate commander, intended less to convey definite orders for his immediate action than to indicate leading features for his general guidance, which should facilitate his judgment in making subsequent decisions.

14. An operation order must contain just what the recipient requires to know and nothing more. It should tell him nothing which he can and should arrange for himself, and will only enter into details when details are absolutely necessary. Any attempt to prescribe to a subordinate at a distance anything which he, with a fuller knowledge of local conditions, should be better able to decide on the spot, is likely to cramp his initiative in dealing with unforeseen development, and should be avoided.

In framing an operation order, therefore, the general principle is that the object to be attained, with such information as affects its attainment, will be briefly but clearly stated; while the method of attaining the object will be *left* to the utmost extent possible to the recipient.

15. The administrative branches of the staff are responsible for drawing up all orders for their particular arrangements in connection with the operations. Such portion of these orders as it is necessary for all recipients of the operation order to know, will be either published in the body of the operation order by the Air Staff (*see* Section 51), or as a supplement to it. A supplementary administrative order is issued by the branch concerned after co-ordination by the Air Staff.

Portions of administrative orders which it is unnecessary for all recipients of the operation order to know will be issued separately to those immediately concerned by the branch responsible for drafting them, after co-ordination by the Air Staff.

16. It is essential that subordinates should be able to work intelligently and resolutely in accordance with brief orders or instructions. Every order is based on an assumption as to the enemy's present situation. If it becomes apparent to the recipient that the assumption on which the order was based is erroneous, then he must be able to take upon himself the responsibility for departing from or varying the order.

17. When, for any reason, separate orders are issued, instead of a combined order, each separate order will include such information regarding other forces as the recipient may find it useful to know.

18. If any portion of the force is to be detached, the commander of the detachment will, if possible, be named in the order. In the case of a detachment made up of different units, a rendezvous, where representatives of units will meet the commander, should be arranged.

19. Orders must be issued in sufficient time to enable subordinate commanders to frame and distribute their own orders. Only necessary matter will be embodied by the subordinate commanders. It should express the intention of the subordinate commander issuing the order arising out of that issued to him by higher authority. The order issued to him should not usually be published for information. A subordinate commander's orders should, however, be sufficiently full to enable those under him to appreciate the situation, and to understand how they may co-operate with others.

20. The distribution by a commander to his subordinates of copies of operation orders received by him from higher authority can seldom be

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justified. Exceptional cases may arise when this may be permissible in order to save time, but the officer who passes on a copy of an order must realise that he is responsible for having made known any information contained in it.

21. During the course of operations it will often be necessary to supplement the orders already issued by further operation orders. These may take the form either of complete fresh orders, or separate orders issued to one or more units or commands. In the latter case, should the original orders be modified to any considerable extent, all other units or commands affected by the new order must be informed of its purport.

22. If detailed orders will be delayed in issue, a preliminary warning order should be sent out as early as possible. This will often prevent inconvenience to units. Verbal orders will be confirmed in writing.

23. Operation orders will not be taken into the air by recipients, nor be distributed by air unless there is no likelihood of their falling into the hands of the enemy.

24. To facilitate the quick digestion and interpretation of orders it is desirable that the same sequence and the same form should always be used. Where the operation, though taking place in a theatre of war, approximates to a peace movement, the form may not be applicable and will not necessarily be adhered to. Paragraph headings are generally desirable.

The normal form of operation orders is as follows:—

(Heading.) SECRET.

..... Group Order No.....

(Reference Order No..... (if required)).

Map reference. Copy No.
Date.

1. (Information)

(*a*) Regarding the enemy.
(*b*) Regarding our own forces.

The general situation should be given under the headings (*a*) and (*b*) above. This will include only such information as is necessary to assist the recipients in carrying out their allotted tasks.

Generally the commander should take the responsibility of stating (*a*) with certainty, but where this is impossible the source of the information should be given.

If it is not desirable to mention the source of information, the degree of credibility attached to it should be stated, and the time when it was acquired.

On the amount of information given under paragraph (*b*) will largely depend the effective co-operation between formations.

To avoid long and complicated orders it may be advisable to place in appendices, details as to the hostile order of battles or the composition of detachments. The tabulation of such details tends to clearness. Important essentials must remain in the body of the order.

2. (Intention.) A concise statement of the intention of the officer issuing the order. It is seldom necessary to look far ahead in stating intentions. Alternative plans and conditional statements depending on development are apt to cause doubt and uncertainty and should be avoided.

3. (Method of execution.) Under this general heading will normally come the paragraphs dealing with the allotment of duties.

4. (Administrative arrangements.) Instructions for supply, transport, ammunition, medical services, etc., will be detailed in this paragraph.

5. (Signals.) This paragraph should give all necessary information concerning the means units have of communicating with one another (*e.g.*, despatch rider, wireless, etc.). In the case of Wireless, details of wavelengths and call signs to be used must be given. The position to which reports are to be sent. Report centres, etc., must always be given.

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6. (Acknowledge.) The use of the word acknowledge signifies "received and understood." Should it be necessary to notify receipt of an order before decoding or digesting the contents, the word "received" will be used.

(Ending.)

Signed.....
Rank.
Appointment.

Issued at.....hours.

Distribution List.

Note.—The time is that at which the orders are actually issued from the office of origin.

The distribution list should be in correct sequence, *e.g.*, formations and units under command, staff and heads of administrative services, war-diary, and file, formations and units co-operating in the operation.

The file copy will show against the name of each recipient in the distribution list, the copy number of the order followed by the method of issue.

Maps and Appendices should be marked with the same copy number as the order to which they are attached.

Movement Orders.

25. Movements by air will be detailed in an operation order, the detail of units being shown clear of the general text of the order.

In the case of movements on a large scale, a separate movement table (on the following lines) should be attached to the operation order:—

Copy No..... SECRET.

Movement table issued with ..... (unit)

Operation Order No..... Dated.....

Serial No.	Date.	Place.		Time due to arrive.	Route.	Height.	Time of arrival of transport.	Remarks.
		From.	To.					

26. When issuing operation orders for movements by land, the units will be detailed in the order in which they are to move.

If units are detailed to operate with protective troops, the order of movement will be arranged by the commander of the latter.

27. The following points should be observed in drawing up orders for the despatch of units by rail:—

(i) Date and place of entraining.

(ii) Time of departure; hour at which units are to reach entraining place, and, if necessary, the road to be used.

(iii) Places of assembly near, but clear of, entraining and detraining stations, and latrine arrangements.

(iv) Composition of train.

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(v) Destination, duration of journey, and railway route to be followed.
(vi) Arrangements for feeding, and for latrines en route.
(vii) Loading and unloading parties.
(viii) Entraining and detraining officers.
(ix) Medical arrangements.

3. INFORMATION.

(See *Operations Manual.*)

1. Timely information regarding the enemy's dispositions and the topographical features of the theatre of operations is an essential factor of success in war.

Information is acquired principally by—

(*a*) Reconnaissance, including photographic reconnaissance.
(*b*) Examination of inhabitants, prisoners, deserters or papers.
(*c*) Intercepting messages.
(*d*) Secret Service.

2. Reconnaissance, apart from fleet or sea reconnaissance, is the service of obtaining information with regard to—

(*a*) The topographical features of a country.
(*b*) The movements and dispositions of the enemy.

In modern warfare this information is obtained to a great extent through the medium of reconnoitring aircraft. Such reconnaissance may be strategical, tactical or protective.

3. In reconnaissances other than those carried out over the actual battle area, the following signs should be noticed as affording information:—

(*a*) *Clouds of dust* show movements of troops or transport or cattle, etc.

(*b*) *Tracks.*—After rainfall the tracks of infantry, cavalry or vehicles across country show up lighter than the surrounding ground; if not again used this track disappears with further rainfall. In strong sunlight these tracks have the appearance of a shallow stream of water.

(*c*) *Trees felled* and lying on the edges of a wood often denote that the wood is used as a camp. Trees are cut down and moved to the edges of a wood to make room for huts or a dump.

(*d*) *Canal traffic* forms a useful guide to activity; barges should be located and counted, and when moving, the direction of the movement given.

(*e*) *Mounted units* may be located by the worn nature of the ground in the vicinity of their horse-lines, and by exercising rings which can be seen very clearly from the air.

(*f*) *Barbed wire* is recognisable by the fresh appearance of the vegetation in its vicinity, due to the fact that it has not been trampled upon.

(*g*) *Bivouac fires* should be located, and counted in the evening or early morning.

(*h*) An *object projecting* above the ground, such as a large artificial mound, is difficult to distinguish from a cavity, such as a mine crater when looked at from the air. The following rule will assist observing officers to distinguish between them when flying over a little-known country:—

Any object projecting above the surface of the ground throws its shadow outwards.
Any cavity in the surface of the ground throws its shadow inwards.

Reconnaissance Reports.

4. To obtain satisfactory results it is essential that the observing officer should be given a clearly defined task, which must be within his powers to perform. Definite instructions are particularly essential in carrying out what is known as Close Patrol reconnaissance.

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5. In drawing up his report the observing officer should be as concise as possible, and should be careful to confine his information to what is relevant.

The most satisfactory method is to render the report on the ordinary reconnaissance report form. The disadvantages of a cut-and-dried form are counterbalanced by the greater ease with which items of information can be referred to, or reports collated.

Care should be taken to report facts only.

All names must be put down in block letters. and spelling should be the same as on the map.

Time is most important.

The Map sheet referred to in connection with the report should be clearly stated.

SQUADRON.

Date	
Left Ground	Pilot .....
Landed	Observer .....
Visibility	Aeroplane .....
Ref. Map	Height .....

Time.	Place.	Remarks.	Action Taken (if any).

Observations by .....
Signature .....

6. *Aerial Reconnaissance of Railheads and Junctions* will be usually accomplished by means of the aerial camera; but photographic reconnaissance should, where possible, be supplemented by visual observation. If an engine and carriages are seen, they must be reported as a train. If there are trucks it should be stated whether they are open or closed, loaded or empty (in the case of open trucks). Thirty trucks without an engine should be reported as Rolling Stock (R.S.) for one freight train; 30 carriages R.S. for one passenger train. If there are less than 30 trucks or carriages the approximate number should be stated. The direction in which a train is moving, time of seeing it and its map position, should always be stated. If a train is halted this should be reported, together with the direction in which it is facing, whether it has steam up or not, its position and the time of seeing it.

7. *Movement of Troops.*—If troops are seen moving, the best way of reporting this movement is to draw a pencil line on the map, showing the road space that the troops occupy, with an arrow at one end of the line to show the direction of the movement (*see* Fig. 1).

The troops should be carefully examined, as it is possible that in order to hide his strength the enemy will move Infantry on one side of the road and Artillery on the other side. The time of seeing the troops must be stated. If they are approaching a road junction, care should be taken to see which road they take.

8. *Transport.*—Motor Transport must be reported as M.T. and Horse Transport as H.T. State whether vehicles are covered or uncovered, loaded or empty, direction of movement and numbers. Barge movement on rivers and canals must be reported.

9. *Hostile Aerodromes.*—If a hostile aerodrome is passed, the number and type of aeroplanes on the ground must be noted; also the number of hangars, transport, location of workshops, power house, repair shops, storage sheds, etc., and roads, and railways serving the aerodrome.

10. *Tactical Information.*—Definite information is specially important when tactical questions are dealt with. Thus it is not sufficient to say

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that enemy troops were seen at a certain point. Information is usually required as to the strength in which they were seen and what they were

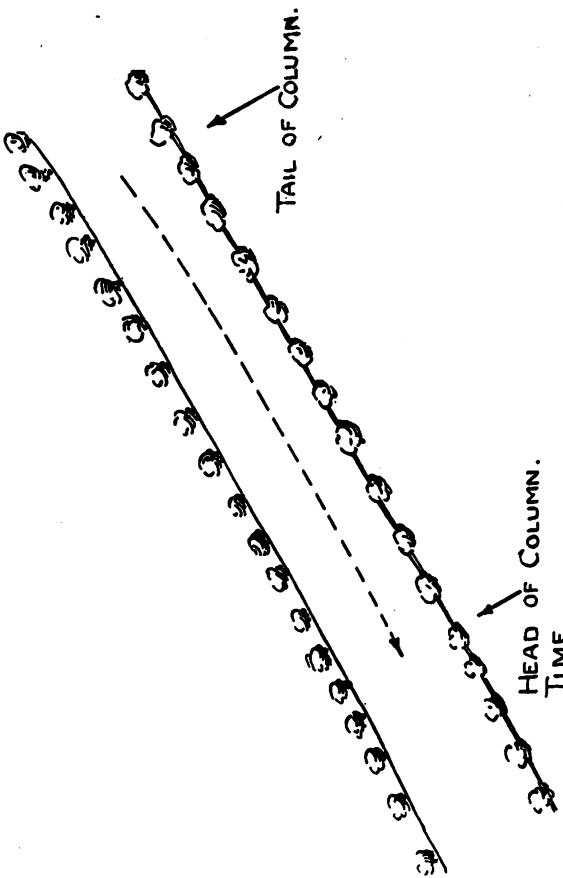

FIG. 1.

doing. Negative air reports of a tactical nature should be treated with reserve; the fact that an observing officer saw no enemy at a certain point does not necessarily signify that they were not there.

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Reconnaissance of a Position.

11. The reconnoitring of a position on which an attack is contemplated will usually be assisted by means of aerial photography; but on certain occasions this may not be possible, in which case a rough sketch map may prove of the utmost value. Every map or sketch, however rough, should have the North Point shown and whether this is true or magnetic indicated.

12. The following are the chief points on which information is desirable:—

(*a*) The general front of the position so far as it can be ascertained, and whether the real position is covered by advanced troops.

(*b*) Localities to which the enemy is seen to be devoting attention and any others which would appear likely to be of special tactical value to him.

(*c*) The position of the flanks.

(*d*) The construction of the trenches and condition of the wire or other obstacles.

(*e*) Machine gun emplacements.

(*f*) Position of reserves.

(*g*) Roads along which reinforcements could move to the position.

Artillery Reconnaissance.

13. Artillery reconnaissance from the air varies with the character of the campaign. In stationary warfare it is largely accomplished by means of air photography, supplemented by visual observation. In moving warfare visual observation must be almost entirely relied upon.

14. It is the duty of the observing officer during a period of stationary warfare to watch the degree of activity of various known hostile batteries already located by other means, and to locate by their activity other batteries not previously located.

15. Flashes of hostile batteries in action are more easily observed and located in the early morning and late at night.

16. An experienced observing officer will be able to gauge the calibre of the gun in action by the nature of the flash. Where possible this should always be reported.

17. The area shelled should be noted and time of flight obtained by means of a stop watch. Information of this nature is of the greatest assistance to the counter-battery staff.

18. New pits can be easily recognised by the quantities of fresh earth thrown up in the vicinity.

19. In carrying out an artillery reconnaissance by means of visual observation the following points should be noted:—

Number of pits, if any, and those occupied.
Strength of pit protection.
Number of guns in position.
Type of gun, if possible.
Size and direction of blast marks.
Direction of tracks leading from the battery position.

Topographical Reconnaissance.

20. Information as to the topographical features of the country can be obtained more quickly by means of aircraft than by any other methods. In unmapped country over which operations are likely to take place, air photography can be of the greatest assistance in the production of useful maps; when the country is in the occupation of the enemy, aircraft will be the only means of obtaining accurate topographical information.

Hints for Observing Officers.

21. (i) Make sure that you understand what you have to do, *i.e.* where you have to go, and what you are to look for.

(ii) Put yourself in the place of the recipients of your report; it will help you to gauge their requirements and to convey a correct impression of what you have seen.

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(iii) The recording of the results of a reconnaissance is a matter equal in importance to the efficient carrying out of the operation itself, since information, however good, is useless if not conveyed rapidly, clearly, and concisely to the recipient.

(iv) The main object is to get the information to the proper authorities; it must be remembered that fighting is a secondary object and must only be indulged in if absolutely necessary.

(v) In the East, where good maps are often not available, easily recognisable features are useful as reference points. These should be given names, if this is not done on the map. Other points can then be identified by their distance and bearing from these reference points.

(vi) It is important when flying over country that has not been accurately surveyed and mapped to note the salient features readily recognisable from the air. "Diamond-shaped village with round clump of trees on northern boundary and round pond, 100 yds. to east"—this will assist others in identifying the village.

(vii) If no enemy is seen at a certain position, make it clear in your report that you did not see any signs of the enemy; but unless you are certain do not say there was no enemy there.

(viii) By flying low over his position you may sometimes induce the enemy to open fire on you; but if he does not do so it does not mean he is not there.

(ix) In locating the position of the enemy during actual battle you must be guided by the colour of his uniform and the fall of hostile shells. The latter is not always reliable, and should only be used in conjunction with the former.

(x) When engaged in a close reconnaissance patrol, do not expect our infantry to reveal their positions immediately you call for recognition signals. Normally a period of about 10 minutes will elapse before a reply is received; the time will vary according to the intensity of the enemy's artillery fire. From the time that recognition signals have been called for you must remain in the immediate vicinity of the front line, otherwise the infantry will imagine that you have gone away and will not reveal themselves.

(xi) It is more difficult to locate the enemy's advanced troops in moving warfare than in trench warfare. The greatest care should, therefore, be taken to locate his outposts accurately in the former case. This can often be accomplished only by drawing his fire (*see* paragraph 14).

(xii) All ambiguities such as "a lot of," "behind," "to the right of," or "left of" should be avoided. Every statement should be as definite as possible. What is surmised and what has been actually observed should be clearly differentiated—guesswork must be entirely eliminated.

(xiii) Owing to the difficulty of report writing in the air, as much information as possible should be recorded by means of conventional signs on a map.

(xiv) When dropping messages to infantry units, come down as low as possible, and always drop the message up wind. You should wait to see that your message is picked up.

4. SIGNALS.

General.

1. **Higher Organisation.**—The successful direction of operations in war depends to a great extent on the provision and maintenance of efficient and adequate means of communication with all parts of the forces concerned, and especially between the different Services when working together.

It is of vital importance that good communications should be available from the Headquarters of the Commanders of the forces to their bases.

2. **Association of Signal Staff with Operations.**—So important are communications that at all conferences of the Operation Staff a representative of the Signal Staff should be present; this principle must be adhered to, not only in the higher commands, but with all units. In higher formations the Senior Signal Officer will be on the Air Staff.

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In cases where alternative plans of operations are being discussed, it is possible that the deciding factor in adopting a certain plan may be the facilities for communication. It must likewise be remembered that the control of communications is greatly simplified if consultation takes place between the Operations Staff and their signal officers before the positions of various headquarters are decided upon, and if, when once such positions are fixed, the moves of headquarters are as few as possible.

3. **Organisation.**—The organisation of the signal officers in the R.A.F. is as follows :—

(i) The Chief of the Air Staff has on his immediate staff at the Air Ministry an officer responsible to him for all the Signal Communications of the R.A.F.

(ii) On the staff of the Air Officer Commanding an Area and for each Group and Wing there is in war time an air staff officer responsible for signals of the Area, Group or Wing with suitable staff. In peace time the organisation is the same as far as possible.

(iii) In most squadrons there is a Signal officer responsible to the Squadron Leader for all the communications of the Squadron.

Additional Signal officers are attached to R.A.F. Formations to co-ordinate the ground reception with the Royal Artillery. All are officers qualified in Visual and W/T Signalling.

Line communications are found by the Royal Corps of Signals.

4. **Signal Communications.**—(i) R.A.F. communications divide themselves into two distinct sections—

(*a*) Ground to Air and Air to Ground.—These are chiefly maintained by Wireless Telegraphy (W/T) and Radio-Telephony (R/T), and are provided and manned by R.A.F. personnel.

Flashing lamps for day and night are used as a subsidiary means of communication.

Sound signalling is used from air to ground, and ground or deck signs from ground to air.

(*b*) Ground to Ground for command and administration work : W/T manned by the R.A.F.

The R.A.F. Signal personnel are trained in both W/T and visual signalling.

For details *see* " The R.A.F. Signal Manual."

(ii) In peace, line telephony and telegraphy is provided by the G.P.O. In war, in naval areas, or when the R.A.F. is working solely with the Navy, telephone lines are arranged by the Navy, but the R.A.F. provides the personnel to operate the R.A.F. exchanges.

On all other occasions in war, line communication for the R.A.F. is supplied, operated and maintained by the Royal Corps of Signals. The arrangements with the Army will be made by the Chief Signal Officer R.A.F., through an officer of the Royal Corps of Signals attached to the Air Staff for the purpose.

Methods of Signal Communication.

5. The advantages and disadvantages of the various methods of intercommunication are briefly considered below—

(*a*) Boat and Despatch Carrier.

Advantages.—Secret and certain, except when under fire. A message of any length or nature—*e.g.*, charts, maps, etc., may be sent. Highly-trained personnel unnecessary. This is the safest form, as only capture of the despatch carrier can result in information falling into the hands of the enemy.

Disadvantages.—Slow.

(*b*) Despatch Carrying by Aircraft.

Only to be used for long distance work of a particularly urgent nature when other methods are unsuitable or impossible.

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(*c*) **Line Telegraphy and Phonography** (*i.e.*, messages sent by line telephone).

Advantages.

(1) Comparative secrecy.
(2) Freedom from disturbance and interference.
(3) Speed of operation.

Disadvantages.

(1) A line is easily cut, when communication ceases altogether.
(2) Liable to tapping.
(3) Difficult to maintain over long distances.
(4) Cannot be used between moving stations, and is difficult to carry to ships.

(*d*) **Wireless Telegraphy.**

Advantages.—Rapid. Easily maintained. Has a good range. A message may be received by any number of units simultaneously. Independent of the nature of intervening country.

Disadvantages.—Certain of interception. Divulges the position of the station or unit transmitting. Liable to jamming. Only a limited number of stations can work in one area. Capacity for work smaller, and reception less accurate than line telegraphy. Requires very skilled operators.

(*e*) **Line Telephony.**

Advantages.—Primarily of use to staff officers for exchanging views. The best method of obtaining an immediate reply.

Disadvantages.—No record of messages exchanged. Great danger to secrecy by interception, as no code is used.

No telephone conversation can ever be considered as safe from overhearing by the enemy or his agents.

(*f*) **Visual, Morse, Lamp, Day and Night.**

Advantages.—Very easy to provide and maintain.

Disadvantages.—Limited range. Liable to interception. Dependent on situation and atmosphere.

(*g*) **Morse Flag.**

Only of use by day. Very limited range.

(*h*) **Heliograph.**

Only used by Navy ashore and Army.

(*i*) **Semaphore.**

Short range, but rapid. Mainly used by the Navy. Mechanical semaphore can be worked from under cover (*see* Figs. 2(*a*) 2(*b*)).

(*j*) **Flag Signalling by the Naval Codes.**

Only used by the Navy, and to a certain extent by aircraft working with the Navy or Coast Stations.

(*k*) **Signalling by International Signal Book.**

Provides a means of communication with commercial shore signal stations, foreign warships, and merchant ships of all nations, particularly if they have no wireless installation.

(*l*) **Deck and Ground Signals to Aircraft.**

Limited in scope. Pre-arranged code essential.

(*m*) **Carrier Pigeons.**

No organization for these in peace-time, but they are obtained from private clubs in time of war. Rapid and reliable by day to fixed points, but it takes time to train birds to return to a special locality, and pigeons will not fly in the dark.

(*n*) **Sound Signalling.**

Slow, but used in fog by the Navy. Used by aircraft to ground.

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(*o*) **Radio-Telephony.**

Advantages.—No specially-trained operators are necessary. Valuable for intercommunication between machines in the air and for special work, such as close reconnaissance patrol.

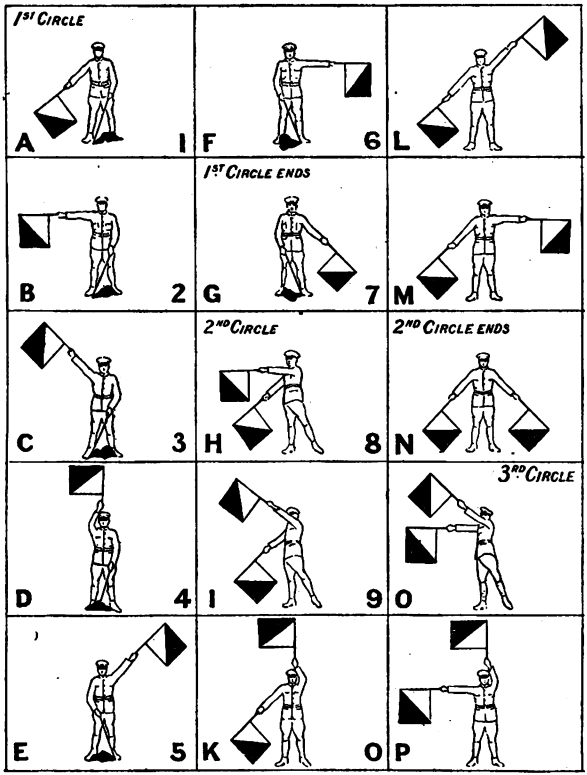

FIG. 2(*a*).

Disadvantages.—All those of W/T. In addition, the intercepted message is at once understandable; the enemy can, therefore, counter any move of ours ordered, and alter his own arrangements to render false the reports that he hears being given. Also interference caused to other stations is more serious than in the case of W/T, and the range obtained from the same power much less than for W/T.

(*p*) **Sound Telegraphy (under Water).**

Only used by the Navy. Limited range. Certain of interception.

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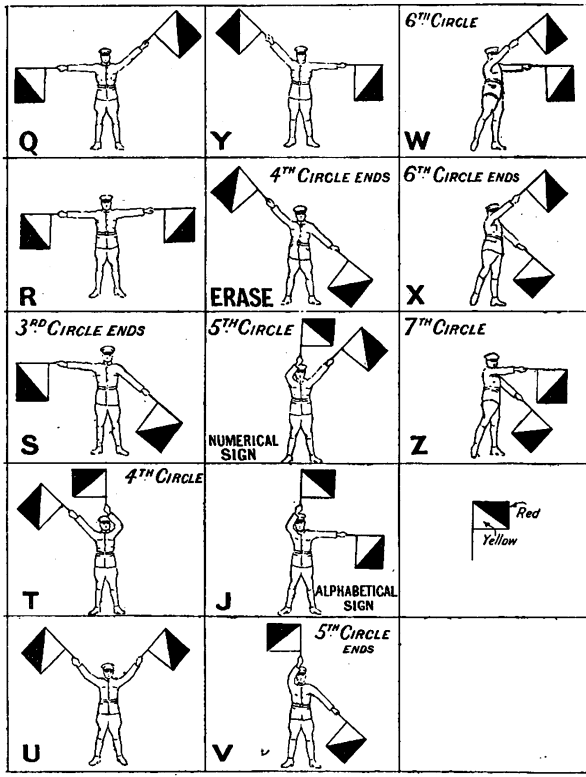

FIG. 2(*b*).

(*q*) **Message Carrying Rockets.**

Maximum range about 1,000 yards, but not easily varied. Divulges positions of both firer and place of landing.

(*r*) **Fireworks (Pyrotechnics).**

Primarily used for recognition and alarm signals; also used for communication between distant aircraft and land and sea forces by pre-arranged systems.

6. (1) Communication for command and supply purposes by line, W/T or other methods is indispensable between formations and units.

Communication between aircraft and ships is vital, and often also between aircraft, and between aircraft and the ground.

(ii) Land line and visual point-to-point communication in war is arranged and carried out for the R.A.F. by the Army (Royal Corps of Signals), under

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arrangements made by Chief Signal officer R.A.F. through an officer of the Royal Corps of Signals.

Wireless point-to-point work is provided and carried out by the R.A.F.

The main Despatch Rider organisation is carried out by the Army under the general D/R System. Provision is made for "special" work of an urgent nature to be carried out by the R.A.F.

(iii) Communication between aircraft, and between aircraft and the ground, is provided and carried out by the R.A.F., with the following exception:—

The Navy provides the apparatus and personnel on board H.M. ships other than aircraft-carriers on which certain W/T apparatus provided by the Navy is operated by R.A.F. personnel.

7. Aircraft employed for any particular operation must be equipped with the wireless apparatus suitable to that operation; the details of this apparatus are laid down in R.A.F. Signal Manual, Part I.

The limitations of the wireless capabilities of the various classes of aircraft must, in all cases, be the governing factor in the communication organisation laid down for the employment of aircraft, and must govern the choice of stations to which they are to report.

8. Only urgent communications are to be sent by telegram. Communications must be sent by letter post whenever practicable.

All telegrams should be written as concisely as possible. Personal pronouns and such words as "please" should be omitted. The reference number and the number of any telegram quoted in the text, should be written in figures; *e.g.*, T.D. 270 your 156 May 1st received.

Drafting of Messages.

9. (i) All service messages, whether telegrams, wireless messages, or phonograms, should be written on the official form (R.A.F. Form 96), and must bear in the appropriate space the signature and appointment of the officer originating the message.

The Signal Staff will not accept messages for transmission unless they bear the clear signature of the originating officer.

(ii) Before handing a message to the Unit Signal Office for transmission, the originator is responsible for completing the message form as follows:—

(*a*) Filling in—

(i) The address to and from. These must be either the name and location of the units, or persons between whom the message is passing, or their authorised abbreviated addresses.

(ii) The text.

(iii) The time of origin, *i.e.*, the time at which the originator signs his message and sends it to the Signal Distributing Office for despatch.

(iv) The degree of urgency.

(*b*) Deleting either the words "as written" or "in code" and inserting the word "Not" if the message is not to be sent by W/T.

(*c*) Inserting any special instructions such as "Not," "Nodeco,"† etc., and signing the form together with his rank and appointment.

(iii) It is of the utmost importance that messages should be worded as briefly as is compatible with perfect clearness, so as to ensure economy not only of expense, but also of time in coding or ciphering, transmission, and de-coding or de-ciphering.

Formalities of phrases or addresses, and all superfluous words are to be omitted (*e.g.*, "submit," "beg to report as follows," "please," etc., etc.).

(iv) Punctuation should not be included in the message unless it is essential to the sense of the message. The word "stop" is never to be used to signify "full-stop," the sign aaa may be used for this purpose.

(v) When a message is addressed to more than one destination, a separate copy of the original telegram should be handed in for each station to which the message is addressed, with all the addresses on each copy in the space "To."

† *Nodeco.*—The message which follows is to be decoded by a commissioned officer.

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This is essential in order that the message may be despatched with the greatest rapidity from the Signal Office. Except in the case of Wireless-messages, only the actual addressee to whom any copy is delivered will appear on the received form, and therefore if the sender wishes all the receivers of messages to realise that it has been sent to certain other addressees this information must be included in the text. The addresses should be contained at the end of the text thus:—"Addressed 'a,' 'b,' repeated 'c,' 'd'."

(vi) In the ordinary course messages are despatched by the Signal Staff in the order in which they are handed in to the Signal Office. In order to ensure that very urgent operational messages should have precedence over ordinary traffic, certain senior officers on all staffs are entitled to mark messages in the appropriated space as "priority" or "emergency" messages. The names of officers entitled to sign such priority messages are published periodically in orders. This privilege is personal, and cannot be delegated to a substitute officer (*see* **R.A.F. Signal Manual, Part I.**).

(vii) In order to identify messages the text should usually commence with the originator's reference number. Former messages should be referred to by—

(*a*) The time of origin, or
(*b*) The originator's number.

In cases where large numbers of messages are originated within one department of a unit, such as the Stores or Repair Depôt, the originator's reference number is generally employed (*see* **R.A.F. Signal Manual, Part I.**).

(viii) When telegrams are handed in, the counter clerk in the Signal Distributing Office will give a receipt with the time of handing in, either in a book or on a form to be provided by the originator. When delivering a message the Signal Staff will require a receipt, either in a book or by the return—signed and timed— of the delivery envelope. If the addressee does not put the time he receives the message, it will be assumed that the message was delivered at the same time as it was received at the Signal Office. This time is entered on the form delivered to the addressee.

(ix) As far as the Signal Office is concerned all messages are confidential, and it is a very serious offence for Signal Personnel to communicate the contents of a message to any unauthorised person. It is equally serious to place airmen in the invidious position of having to refuse to comply with the request of an officer which, in the interest of all concerned, should never have been made.

No officer or airman is under any consideration allowed in the operating part of the Signal Office without the express permission of the Signal Officers on duty.

Phonetic Alphabet.

10. The following Phonetic Alphabet is in general use throughout the Fighting Services, and is to be used in all cases where, in order to avoid phonetic errors, substitutes are required for spelling out doubtful words, names, etc., in telephone messages:—

A.—Ac.
B.—Beer
C.—Charlie
D.—Don
E.—Edward
F.—Freddie
G.—George
H.—Harry
I.—Ink
J.—Johnnie
K.—King
L.—London
M.—Monkey
N.—Nuts
O.—Orange
P.—Pip
Q.—Queen
R.—Robert
S.—Sugar
T.—Toc
U.—Uncle
V.—Vic
W.—William
X.—X-ray
Y.—Yorker
Z.—Zebra

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FIGURE 3.—MORSE, LETTERS AND SIGNS.

Letters.		Figures.	
A	• —	1	• — — — —
A′	• — • —	2	• • — — —
B	— • • •	3	• • • — —
C	— • — •	4	• • • • —
D	— • •	5	• • • • •
E	•	6	— • • • •
E′	• • — • •	7	— — • • •
F	• • — •	8	— — — • •
G	— — •	9	— — — — •
H	• • • •	0	— — — — —
I	• •		
J	• — — —		
K	— • —		
L	• — • •		
M	— —		

Punctuation and Special Signs used in Procedure.		Write
Numeral	• • — • • •	$\overline{\text{FI}}$
Colon	— — — • • •	:
"Full Stop" aaa	• — • — • —	,
Interrogation (also Repeat)	• • — — • •	? also $\overline{\text{IMI}}$
Exclamation...	— — • • — —	!
Apostrophe	• — — — — •	'

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FIGURE 3—*continued.*

Letters.	Punctuation and Special Signs used in Procedure.	Write
N — •		
N′ — — • — —	Hyphen ... ... — • • • —	—
O — — —	Oblique Stroke ... ... — • • — •	/
O′ — — — •	Parentheses (brackets) ... — • — — • —	( )
P • — — •	Inverted Commas ... ... • — • • — •	" "
Q — — • —	Underline (also Block Letters) • • — — • —	UK
R • — •	Commencing Sign ... ... • • • — •	VE
S • • •	Erase ... ... • • • • • • • • • • about ten times	
T —	Separative Sign ... ... • • • •	=
U • • —	Long Break Sign ... ... — • • • —	BT
U′ • • — —	Ending Sign... ... ... • — • — •	AR or +
V • • • —	Bar Sign ... ... • — • • —	
W • — —		
X — • • —		
Y — • — —		
Z — — • •		

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5. CIPHERS AND CODES.

Employment of Codes and Ciphers.

1. The following paragraphs indicate the general rules to be followed in the use of Ciphers, Confidential Codes and Plain Language in Service Messages.

2. The means available for conveying Service Signals are as follows :—

(i) *High Grade Ciphers* will be employed for all secret messages which require a very high grade of security. These Ciphers will be handled invariably by officers of commissioned rank.

(ii) *Low Grade Ciphers and Confidential Codes* will be employed for secret messages for which a lesser degree of security is required than those falling under (i) above. These Ciphers and Confidential Codes will usually be handled by officers of commissioned rank, but may, under certain circumstances, be handled by airmen in the execution of their duties.

(iii) *Codes* will be employed for economic purposes only. The Government Telegraph Code or other similar codes employed under this heading are used for economic purposes. They do not secure secrecy and are cryptographically equivalent to Plain Language.

3. The decision as to whether Cipher, Confidential Code or Plain Language is to be used rests with the originator. In this he should be guided by the circumstances prevailing at the time and the intended route. It should be borne in mind that the substance of the message is not merely confined to its actual meaning, but its effects on other messages and the circumstances under which it is to be sent. Also it must be remembered that replies to Cipher and Confidential Code messages should usually be made in the same Cipher or Confidential Code as was used in the original message.

It may, however, sometimes be necessary to reply to Plain Language messages in Cipher or Confidential Code, or to a Confidential Code message in Cipher.

4. When despatching messages in times of peace, it may often be necessary that matters in advance of events be kept secret. When the events later become public knowledge, the continuation of the use of Cipher or Confidential Code for messages relating thereto is then not only unnecessary but undesirable.

In such cases when the subject-matter of a series of messages in Cipher or Confidential Code is no longer secret, further messages may be de-graded into Plain Language, provided that in the de-graded message—

(i) No reference at all is made to the office reference numbers, serial numbers or times of origin of any previous messages in Cipher or Confidential Code.

(ii) The wording is so chosen as to avoid giving messages any appearance of being in answer or in reference to previous messages in Cipher or Confidential Code.

On no account is this to be read as approving the de-grading of messages from a more to a less secret Cipher or Confidential Code.

The action regarding the de-grading of messages must always be initiated by the originator of the first message of the series.

5. In long messages it frequently occurs that quite a small portion of the context of the message is secret or confidential. In such cases it is advisable to extract that part of the message which is of a secret or confidential nature and to despatch it as usual in a Cipher or Confidential Code. The remainder of the message can then be sent in Plain Language. When this procedure is adopted the greatest care is to be taken not to refer in the Plain Language message in any way to that portion of the original message which has been transmitted in the form of Cipher or Confidential Code.

6. When a message is to be transmitted by W/T over any part of its route, it is to be considered as a " W/T Message."

When the originator considers that a message must not be passed by W/T at any point of its route the word " NOT " must be inserted in the space provided on the Message Form.

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7. When a Cipher Book is being employed, strict compliance is to be observed with the instructions contained at the commencement of each such book.

The de-cipher (transcript of message received in Cipher) has a secret character of its own altogether apart from the subject matter of the message. The fact that the subject matter of a message ceases to be secret does not reduce the necessity for maintaining the secrecy of the de-cipher.

A Cipher message must on no account be confirmed in Plain Language by post or telephone or otherwise.

On no account must the de-cipher of a Cipher message be sent through the post. If it is desired to forward a Cipher message to another point, this must be done by sending the message in its actual enciphered form exactly as received.

No reference is ever to be made in a Plain Language or Economic Code message to the reference number or contents of a Cipher message.

The reply to a Cipher message must invariably be despatched in the same Cipher.

When correspondence ensues on the subject matter of a Cipher message such correspondence is to be conducted under secret cover, and all allusion to the Cipher message must carefully be avoided.

Secret and Confidential Books.

8. All Ciphers, Confidential Codes, and Secret and Confidential books are in charge of an officer (usually the Signal officer), and when not in actual use are to be kept under lock and key in a safe or steel chest. Confidential publications relating to W/T communications, such as W/T instructions, Confidential Call Sign books and W/T operating signals, for the use of the operators in the course of their duties, may be issued to and retained in W/T offices. When not actually in use these publications must be locked up in the steel chest provided for the purpose. They should be inspected and checked by an officer daily.

9. The supply of Secret and Confidential publications is made by the Air Ministry to the Officers Commanding Areas or independent commands, who are the distributing authorities for all units under their command. All applications for, and all questions relating to, such publications are to be forwarded through the usual channels to distributing authorities.

All such correspondence is to be made by a Secret or Confidential letter, as not only are the contents of such books to be regarded as secret, but also the fact of the existence of all such books is to be carefully guarded.

10. The delivery of Ciphers, Codes and Confidential signal books is, in all cases, to be undertaken by an officer; in no case should these documents be despatched by post or by airmen. Other secret and confidential documents, in the absence of special instructions to the contrary, may be sent by registered post after being enclosed in two covers.

Each issue will be accompanied by a Supply note (Form 727 Supply) and Receipt note (Form 727 Receipt). After checking, the receipt note, duly signed, is returned to the distributing authority and the Supply note filed in Guard Book 394, which should support all secret and confidential documents on charge in the register. Immediately on receipt, Secret and Confidential publications should be taken on charge on form 728, which, when filed in the loose leaf binder (Book 393), constitutes the register.

11. The greatest care should be exercised at all times to prevent unauthorised persons having access to the Secret and Confidential books, the compromise of which entails the immediate preparation and distribution of new books.

6. MAPS, CHARTS AND FIELD SKETCHES.

1. General.—Maps and Charts are representations on a flat surface of the curved surface of the earth. A map seldom gives any indication of the shoals, banks, rocks, etc., below mean-sea-level, and a chart rarely gives good information about Topography above High Water Mark.

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CHARACTERISTICS USED ON BRITISH ORDNANCE SURVEY MAPS.

1 Inch Scale

Metalled Roads. First Class
" " Second Class
" " Third Class
Unmetalled Roads
Footpaths
Railways, Single Line
" Two or more Lines
Mineral Lines and Tramways
Woods

Fenced: 5 (Mile distance) / (Altitude) 211
Unfenced

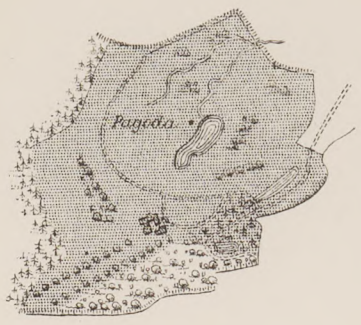
Level crossing — Stations
Cutting — Embankment
Bridge over — Bridge Under

Church or Chapel with Tower
" " Spire
" without Tower or Spire
Windmill — Windpump
Letter Box — L.B.
Lighthouse
Lightship
Beacon

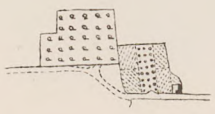
Boundaries County
Parish
Contours 300 / 200
At Villages { Post Office — P. / Post & Telegraph Office — T.

Rivers and Streams when exceeding 15 feet in width are shewn with two lines.

1 Inch & 6 Inch Scales.



Parks and Ornamental Ground



Orchards & Gardens

Woods (Deciduous Trees)

Fir Plantations

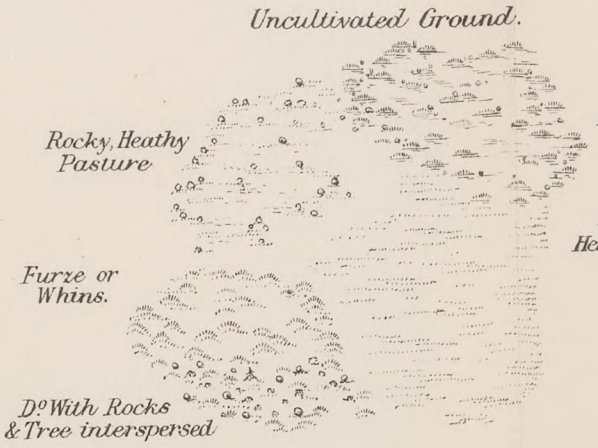
Canal and Tunnel.

Canals.

Marl Pit. Well.

Gravel Pit. Quarry.

Uncultivated Ground.



Trigonometrical Point.

6 Inch Scale.

Double Line of Railway.

Single Line of Railway.

Levelling

All altitudes are given in feet above the assumed Mean Level of the Sea at Liverpool

Contour altitudes are written thus 200

All other altitudes along roads, and to Trigl Stations, obtained by Spirit Levelling are written thus 300· the dot shewing the spot whose altitude is given.

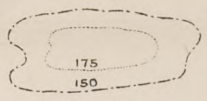
Altitudes with the letters B.M. marked ↑ against them refer to marks made on buildings, Walls, Milestones, &c.

The altitudes at the Trigl Stations are given of the surface of the ground and also of the upper side of the centre stone marking the Station.

Contours & Altitudes

Instrumental Contours
Interpolated dº

thus:-



Description of Specimen Boundary shewing the initials.

Centre of Stream — C.S. C.S.
Centre of Road — C.R.
S.S.
Side of Stream or Drain — S.D. S.D. S.S. S.S.
Root of Hedge, Face of Cop, Side of Fence — S.F. R.H. R.H.
Face of Wall — F.W.
4ft R.H.
4ft R.H. 4ft R.H.
4 feet from Root of Hedge or Fence &c. — 4ft R.H. 4ft R.H.
4ft R.H.
4ft R.H. 4ft R.H.
Centre of Fence, Top of Cop, Centre of Wall, &c. — C.F. F.C. C.W.
Defaced or Undefined Track of Stream Drain or Fence — Def. F.S. Und.

Boundaries 6 Inch Scales.

Counties & { Civil Parishes or Townships }
Counties { Civil Parishes or Townships }
Parishes (Mother or Ancient) †
Parliamentary Borough — Parliamentary Boro' Bdy.
Municipal Boundary — Municipal Boundary.
Liberties, Honors, &c.
Wards of Corporate Towns.

Fig. 4a.

1670, 298º 10163/10 7003 1..25.

Malby & Sons, Lith.

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A map is generally made so as to show a minimum of distortion, but is not specially adapted for navigating. A chart primarily for navigation is so made that any line drawn across it cuts all meridians at the same angle, but it distorts the scale and area of the surface.

A map is usually printed in colour, a chart is generally printed in black only.

A Field Sketch is a hastily prepared large scale map of some area of immediate importance.

2. **Sheet Lines** are the lines or curves enclosing the area mapped on each sheet of a map or chart.

(1) *Maps.*—In general there are two classes of Map Sheet Line—

A. Geographical (the representation of meridians and parallels).
B. Rectangular.

In (A) the side lines are formed by meridians, the top and bottom lines by parallels of latitude.

The sheets vary in dimensions according to the latitude and longitude (*see* A in Figure 4).

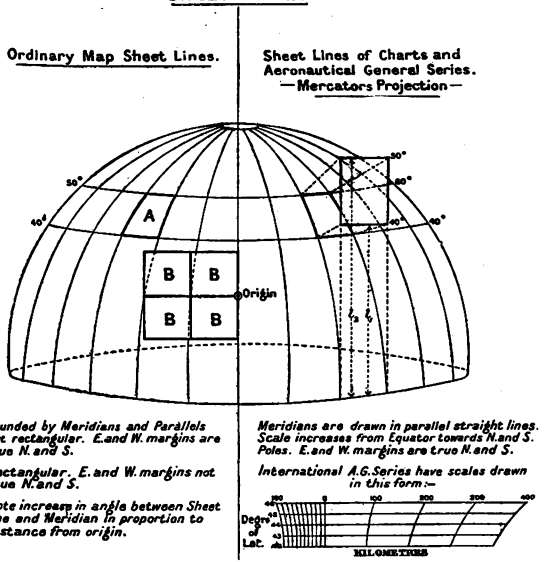
SHEET LINES
Ordinary Map Sheet Lines.
Sheet Lines of Charts and Aeronautical General Series.
—Mercators Projection—
50°
50°
40°
40°
60°
60°
A
B
B
B
B
Origin
A. Bounded by Meridians and Parallels Not rectangular. E.and W. margins are true N. and S.
B. Rectangular. E. and W. margins not true N.and S.
Note increase in angle between Sheet line and Meridian in proportion to distance from origin.
Meridians are drawn in parallel straight lines. Scale increases from Equator towards N.and S. Poles. E.and W. margins are true N.and S.
International A.G.Series have scales drawn in this form:—
0
100
200
300
400
Degrees of Lat.
KILOMETRES
Note The illustration of Mercator's Projection is purely diagrammatic. This projection is not geometrical. The values of t, and t2 giving the Mercator Latitudes are computed.

FIG. 4.

Examples of this type are: Maps of the Survey of India, British Africa, United States, etc., and small scale maps generally.

In (B) the sheets form part of a rectangular series, and are all of the same dimensions. The vertical sheet lines are not drawn North and South. *See* B.B..... in Figure 4.

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Examples of this type are: Maps of the Ordnance Survey in general—French 1/80,000—and large scales generally.

(2) *Charts.*—The vertical sheet lines are meridians; but are drawn parallel and true North and South. The horizontal sheet lines are parallels of latitude.

Examples of this type are: Admiralty Charts and International Aeronautical General Series.

3. Map Scale.—The ratio of the distance between two points as measured on the map to the horizontal distance between those points on the ground.

It is usually illustrated by a printed scale graduated in appropriate units (*e.g.*, feet, metres, etc.); and described in either or both of the following ways:—

(*a*) By the Representative Fraction (R.F.), *e.g.*, 1/63360; $\frac{1}{100,000}$, etc.

(*b*) As so many inches or centimetres to the mile or kilometre respectively.

The Representative Fraction indicates, by its denominator, the distance on the ground represented by unit distance (*i.e.*, its numerator) on the map.

Thus a R.F. of 1/63360 indicates that 1 inch (say) on the map represents 63,360 inches (= 1 Mile) on the ground. The scale, can, therefore, be described as one inch to 1 Mile.

When only the R.F. is given—(1) To find the number of statute Miles to the inch—

Divide the denominator by 63,360:

$$\text{Ex: R.F.} = \frac{1}{80,000} : \frac{80,000}{63,360} = 1{\cdot}263 \text{ miles to 1 inch.}$$

(2) To find the number of inches to the statute Mile—

Divide 63,360 by the denominator of the R.F.

$$\text{Ex: R.F.} = \frac{1}{80,000} : \frac{63,360}{80,000} = {\cdot}792 \text{ inches to 1 mile.}$$

Scales are practically uniform over ordinary maps between 1/1,000 and 1/1,000,000. On very small scale maps and atlases the scale is generally noticeably variable.

4. Squared and Gridded Maps.

(*a*) *Squared Map.*—One that is divided up regularly into squares for the sake of reference.

(*b*) *Gridded Map.*—One which shows the representation of a rectangular co-ordinate system.

A squared map is not necessarily a gridded map, because the squares may be drawn without regard to any particular system, and may have no connection with the squares of an adjoining sheet.

The essence of a gridded map, on the other hand, is that the squares are drawn on a regular system which is continuous over a large area. The grid system is based on a definite point as origin of the co-ordinates, on a definite line which fixes the orientation, and on a definite form of projection. It refers to an area and not to a map.

The grid adopted for co-operation between all arms is built up as follows:—

The area is covered with a continuous network of lines forming squares of, say, 1,000 metres side.

The axes, Grid North and Grid East, are drawn true North and East through the origin of the rectangular co-ordinates, and the other lines of the system are drawn parallel to them.

Starting from the origin, every tenth grid line is emphasised. These emphasised lines form squares of 10 kilometre side, and each is given a letter. In a square of 50 kilometre side there are twenty-five 10 kilometre squares, lettered A to Z, omitting I. Each kilometre square is given a 2-figure number, which represents the co-ordinates of its SW corner in kilometres measured from the SW corner of the large lettered square. The first figure gives the number of kilometres East, the second figure the

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Figure 6.

CONVENTIONAL SIGNS & LETTERING USED IN FIELD SKETCHING

Note: Words which should appear on the Sketch are shewn in black

Fields with walls, hedges, fences, ditches or any obstacle.

Road enclosed by hedge, fence, ditch or obstacle of any kind

A 2 Miles

B 4 Miles

C 6 Miles

Embankment

Cutting

Hops 10' high

Wheat 4' high

It is unnecessary to state the nature of the cultivation unless such information is required by the object of the sketch

Heath

Orchard

Rough Pasture

Cliffs

Quarry or precipitous ground

Sand

Lake

Stone

Wood

Bridge with piers.

Iron

Ford

Ferry

Bridge

Marsh

Marsh

state nature of foreshore & at what state of the tide it is practicable for landing

Road without fence etc.

P 1 Mile

Q 2 Miles

Unmetalled

R 3 Miles

Nature of wood to be given in writing thus:- "Oak" "Pine" etc & whether passable or impassable & by what arm

Brown tint denotes metalled road If brown colour is not available the word "Metalled" or "Unmetalled" should be inserted

Wood

or

Width 10 ft

R. AVON

Flying bridge

Lighthouse

L.H.

Footpath

Obstacles

Church or Chapel

with Tower

with Spire

without Tower or Spire

Windmill

BRITISH TROOPS

Mounted Troops (add M. I. if mounted Infantry)

In Line.

Column of route

Other formations

Vedette

Artillery

Guns in action

Guns on march

Embankment

Railway

Cutting

Single or Double

HAWLEY 4 Miles

Bridge

Brick or Stone

Tunnel

Sta.

Station

level crossing

to EYNSFORD 6 Miles

Telegraph

entrenchments

When there is not sufficient time to draw the cross-bars a railway may be shewn by a broad black or red line with the word "Railway" written along it

Infantry

In Line

Column of route

Other formations

Sentry

Transport

On march

Parked

Opposing forces coloured blue

15°

Magnetic

ABBREVIATIONS

P. Post Office

T. Telegraph Office

S.P. Sign Post

oW. Well

Clearance or Demolitions

Villages

Scale 4" to 1 Mile

Inn

Forge

HAWLEY

under 4" to 1 Mile

EYNSFORD

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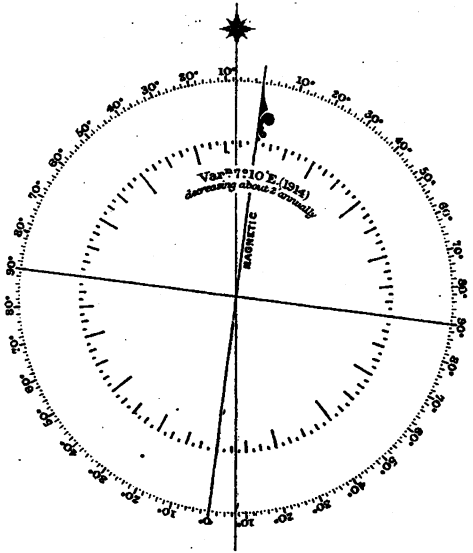
Pattern of Compass (prior to June 1911), drawn on the Magnetic Meridian.



The figures in brackets, either before or after the Variation, denote the year for which it is given.
All Bearings are Magnetic, except when otherwise stated, and are referred to the nearest compass on the chart.

Figure 7.

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Tides and Tidal Streams

H.W.F. & C. IX^{h} 25^{m} ..... *High Water Full & Change. The hours are expressed in Roman Figures, except 2^{h}*

Equin^{l} ..... *Equinoctial*

Fl., fl. ..... *Flood*

* *H.W.* ..... *High Water*

† *H.W.O.S.* ..... *Ordinary Springs*

h. ..... *hour, hours*

kn ..... *knot, knots*

* *L.W.* ..... *Low Water*

† *L.W.O.S.* ..... *Ordinary Springs*

M.H.W.S. ..... *Mean High Water Springs*

M.L.W.S. ..... *Low*

m ..... *minutes*

Np. ..... *Neap Tides*

† *ord.* ..... *ordinary*

Q^{r}. ..... *Quarter*

Sp. Spr. ..... *Spring Tides*

Current

Flood Tide Stream

Ebb " "

* *H.W. or L.W. always refers to Mean High Water or Mean Low Water of Spring Tides, unless otherwise stated.*

† *These terms will not appear on new charts or new editions of charts published subsequent to June 1914*

The period of the tide, at which the streams are running in the direction of the arrows is denoted as follows:–

(1) *1st Q^{r}, 2nd Q^{r}, etc. for the Quarters of each Tide* ..... ← 2nd Q^{r} 2nd Q^{r} →

(2) *I^{h}, II^{h}, III^{h}, etc. for 1st, 2nd, 3rd hours after High or Low Water* ..... ← II^{h} III^{h} →

(3) *Black dots on the arrows. the number of hours after High or Low Water. (The reference being to High or Low Water in the locality, unless otherwise stated on the chart)*

3 hours after High Water, and 3 hours Ebb are both indicated by .....

4 ..... Low ..... and 4 hours Flood .....

The Velocity of Currents and Tidal Streams is expressed in knots, thus:– ..... 1 kn 5 kn

The Rise of Tide is given above the Datum of the chart.

The Datum to which soundings are reduced, unless otherwise stated, is approximately Mean Low Water of Spring Tides.

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General Remarks

Charts are generally drawn on the True Meridian; if otherwise, a True Meridian is given on the chart.

Soundings are expressed in Feet or Fathoms, as stated in the title of the chart.
1 Fathom = 6 Feet = 1·828766 Metres.
Underlined Figures, on Rocks and Banks which uncover, express the Heights in Feet above the Datum of the chart, unless otherwise stated.
All Heights (except those expressed in underlined figures as above) are, unless otherwise stated, given in Feet above Mean High Water Springs, or, in places where there is no tide, above the Level of the Sea.
The Natural Scale is the proportion which the scale of the chart bears to the actual distance represented, and is shown thus :– $\frac{1}{12,150}$
A Sea Mile is the length of a minute of Latitude at the place, and a Cable is assumed to be a tenth part of a Sea Mile.
The Figures in Brackets in the bottom right-hand corner of a chart, thus :– (38·43 × 25·49) *are the dimensions of the plate in Inches between the innermost graduation or border lines.*
All Longitudes are referred to the Meridian of Greenwich.

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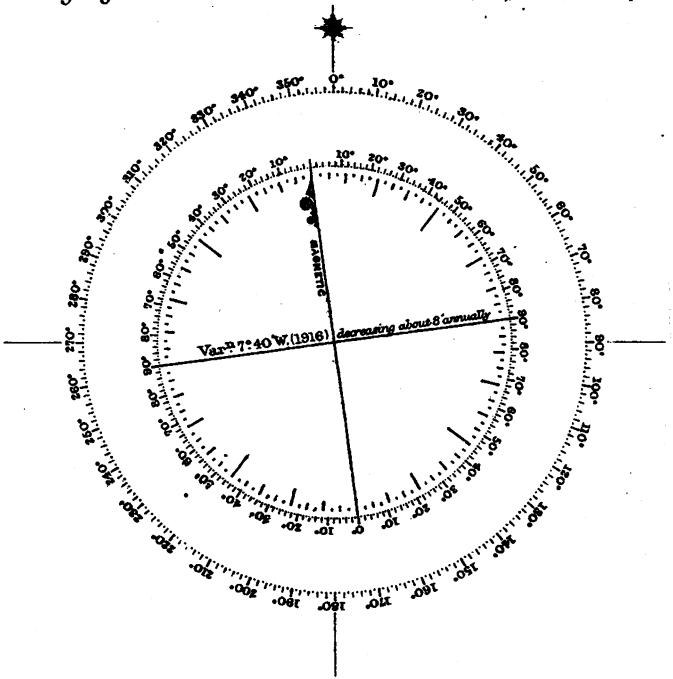
Pattern of Compass adopted after June 1911,
now being engraved on the Chart Plates when new compasses are required.



Note:- *When a compass of the above pattern is shown on the Chart Bearings are given both True and Magnetic thus 298° (N.54°W.Mag.) and this is stated in the Title.*
The figures in brackets after the Variation denote the year for which it is given.

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Buoys and Beacons

Light Buoys

Bell Buoys

Can Buoys

B W R

H.S V.S Cheq

Conical Buoys

B W R

H.S V.S Cheq

Spherical Buoys

H.S W

Buoys with Topmarks

Spar Buoys

Mooring Buoys

Fixed or Floating Beacons

Light Vessels or Floats

The Position of a Light Vessel, Buoy or Beacon is the Centre of the Base, and is usually indicated by a small circle.

B., *Blk*..... *Black*

Cheq..... *Chequered*

G..... *Green*

Gy..... *Gray*

H.S... *Horizontal Stripes*

Nº..... *Number*

R..... *Red*

S.B..... *Submarine bell (Sounded by wave action.)*

S.F.B. ..... *Submarine Fog Bell (Mechanically sounded)*

V.S..... *Vertical Stripes.*

Y..... *Yellow*

W., *Wh*.... *White*

The Heights given against Beacons or marks forming beacons (such as Chimneys) represent the Height of the Top of the object above Mean High Water Spring Tides, or above the Sea level where there is no tide.

1670.2989 10163/10.7000.1·25.

Malby & Sons, Lith.

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Conventional Signs used in Admiralty Charts.

Trees

Firs

Palms

Casuarinas

Cultivated Land

Swampy, Marshy or Mossy Land

Sand Hills or Dunes

Cliffy Coast line

Steep Coast

Sandy shore

Stony or Shingly shore

Mangroves

Figures bracketed against islands and rocks express the Heights in Feet above Mean High Water Springs, or above the sea in cases where there is no tide.

(51 high)

(350)

Towns, Villages or Houses

Villages or Houses

Roads

Track or Footpath

Railway

Tramway

Churches or Chapels

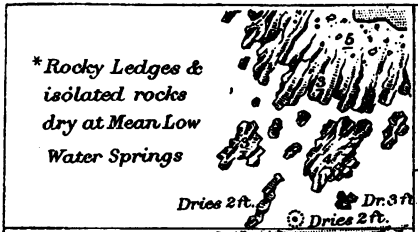
Temples

Windmill

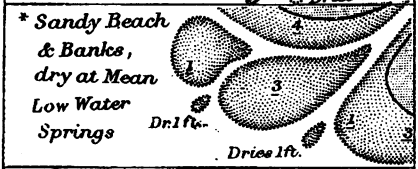
Triangulation Station

Beacon, Chimney, Flagstaff or other fixed points

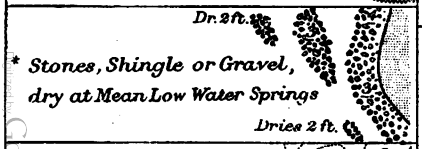
Lights, Position of



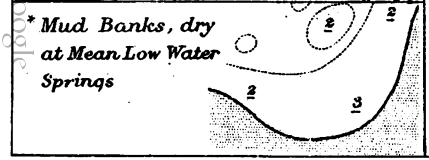
* Rocky Ledges & isolated rocks dry at Mean Low Water Springs



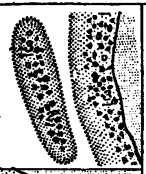
* Sandy Beach & Banks, dry at Mean Low Water Springs



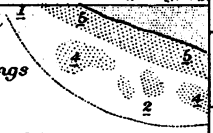
* Stones, Shingle or Gravel, dry at Mean Low Water Springs



* Mud Banks, dry at Mean Low Water Springs



* Sand & Gravel or Stones, dry at Mean Low Water Springs



* Sand & Mud, dry at Mean Low Water Springs

* The Underlined Figures, on the Rocks & Banks which uncover, express the heights in feet above the datum of the chart, unless otherwise stated.

Signifies 1 fathom line

2 " "

3 " "

4 " "

5 " "

6 " "

10 " "

20 " "

50 " "

100 " "

Coral Reefs

Rock awash at Mean Low Water Springs ✳ or (✳)

Rock with less than 6 feet of water over it + or (+) at Mean Low Water Springs

On small scale charts, this symbol is used for rocks with greater depths of water over them.

Rocks with limiting Danger line

Rock or Shoal, the Position of which is Doubtful (+) P.D (5) P.D

Reported Rock or Shoal, the Existence of which is Doubtful

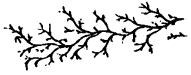
D
E.D E.D

Breakers along a shore

Overfalls & Tide Rips

Eddies

Kelp



Beds of Edible Sea Weed

Signifies no bottom found at the depth expressed

70 100

Anchorage for large vessels

.....,.....,,...small.....,.....

Fishing Stakes

Wrecks

Where depth over is known

5½ Wreck (1911)

Partially or wholly submerged where depth over is unknown

Wreck (1911)

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number of kilometres North. These letters and numbers are printed on the map. Along the margin are printed numbers which represent the distance in kilometres of each grid line East or North of the origin. Every tenth (emphasised) line has this number in full, while the intervening lines are numbered 1 to 9. (*See* Figure 5.)

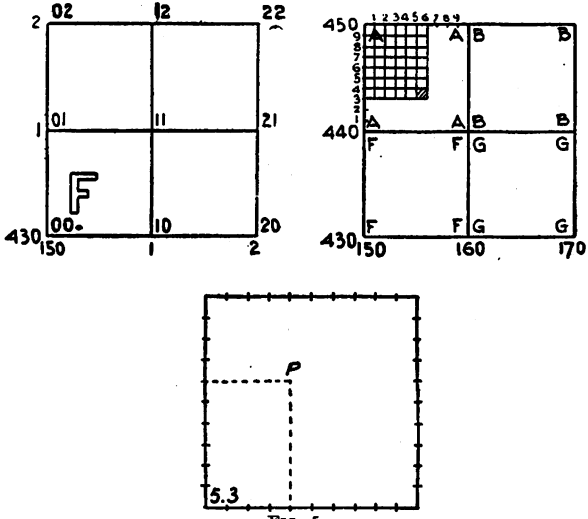

FIG. 5.

The position of a point is described by its co-ordinates. Thus, suppose the position of P. measured in the usual way is 410 metres East and 620 metres North of the SW corner of the small square 53; then the position of P. is 5,410 metres East, 3,620 metres North of the SW corner of the big square A.

Thus, the pin-point co-ordinates of P. are A.5, 41–3, 62. These give the position of P. to the nearest 10 metres. If the position to within 100 metres is all that is required, 4 figure co-ordinates would be used; thus A.5, 4–3, 6. If great accuracy is required, 8 figure co-ordinates can be employed.

Since the SW corner of square A. is given (by the Marginal Figures) as 150 kilometres East and 440 kilometres North of the origin, the co-ordinates of P. with respect to the origin are 155,410 metres East, 443,620 metres North. Example 1/20,000 and 1″ to 1 mile gridded series. *Conventional Signs* provide a convenient and concise means of giving information on a map.

The various Nations employ different symbols, but the conventional signs used are described in the sheet margins of the majority of maps. In some cases the conventional signs are not described on each sheet, but are tabulated on a "conventional-sign" sheet which forms part of the series.

Certain approved Military conventional signs are given in Fig. 6.

5. **Relief.**—Hill features are indicated in one or more of the following ways:—

(*a*) *Contours.*—A contour is the representation of an imaginary line running along the ground at a constant height above mean-sea-level.

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The Vertical Interval (V.I.) is the difference in level between two successive contours. The height of a contour is usually printed against it at intervals throughout its length.

The Horizontal Equivalent (H.E.) is the distance in plan between two adjacent contours.

(b) *Form-Lines* are approximate contours.

(c) *Hachures.*—These are lines drawn down the directions of steepest slope. They give a good general idea of the shape of the ground, but supply little positive information. Hachures are apt to convey a false impression as to degree of slope. The French 1/80,000. the German 1/100,000 and the Austrian 1/75,000 are examples of the hachured map.

(d) *Shading* is similar in principle to Hachuring, but the effect is produced by depth of tint. The light is usually assumed to be oblique. Examples: ½ inch. map of Great Britain; 1/50,000 map of France.

(e) *Layer Tints.*—The area between contours is coloured by tints, which vary according to the level. It fails to show minor variations in relief.

A spot height is the record on a map of the exact height at a particular point.

6. The Compass.

Magnetic Variation (or *Declination*) is the angle between true and magnetic north. It varies according to position on the earth's surface, and is modified by an annual change of the order of 7 minutes of arc.

Deviation.—Compasses fitted in aircraft are also susceptible to attraction due to metal parts, and this varies with every direction of the aircraft-head. The amount for each point is determined and inscribed on a tablet fixed near the compass.

To convert True and Magnetic bearings:—

When the Variation is West.

To find the True when given Magnetic bearing—Subtract the variation. If the result is minus, subtract it from 360°.

To find the Magnetic when given True bearing—Add the variation: If the result is greater than 360°, subtract 360° from it.

When the Variation is East.

To find the True when given Magnetic bearing—Add the variation: if the result is greater than 360°, subtract 360° from it.

To find Magnetic when given True bearing—Subtract the variation: if the result is minus, subtract it from 360°.

7. Map-setting.—A map can be "set," *i.e.*, laid out so as to correspond with the ground it represents, in two ways:—

(a) *By compass.*—Turn the map until the magnetic north point and the north point of compass agree, drawing the magnetic north, if not already shown, at its correct angle (+ or − to true north).

(b) *By objects.*—A map can be set by eye as follows:—

(1) The observer identifies on the map the spot where he stands. He then identifies on the map some distant object that he can see joins these two points on the map by a straight line, and turns the map. He then identifies on the map some distant object that he can see, about the point representing his position until this line points to the distant object.

(2) If the observer cannot identify his position, he can set the map by placing himself in prolongation of a line joining, or between, any two visible objects which can be identified on the map. He then joins the two points on the map, and revolves the map until this line points to the two objects.

8. Map Reading is the art of understanding the ground from its pictorial representation on a map. In air pilotage it further consists of being able to recognise features of the country as seen from the air.

(*a*) Note Title, information in the margins, north point, date of survey, conventional signs, etc.

(*b*) Note the scale, which is the key to distances.

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(c) Note method of showing relief.
(d) Note the position of hill features, rivers, railways, roads and prominent objects.

9. **Cross-Country Flights.**—Before leaving the ground lay off the course between the point of departure and the objective. Along the line so drawn note and memorise all objects of importance such as railways, rivers, towns, villages, churches, tall towers or chimneys, large woods, etc.; the estimated time of passing over various prominent landmarks on the course should be noted on the map against each object, so that, when flying, the compass course can be checked by referring to these objects, and observing if the actual course made good brings the aircraft over them at the estimated times. Should the pilot meet fog or low clouds, he will then be in a position to continue the flight by compass in full confidence that he is maintaining his correct course.

Determine the height of flight necessary to clear the hill features met with.

This is of special importance in misty or cloudy weather, remembering that the altimeter or height-recorder will show the height of the aircraft above the point of departure, and not necessarily above the point of arrival or any places on the route.

10. **Charts.**—Admiralty charts are of four kinds:—

(1) World charts.
(2) Ocean charts.
(3) General charts.
(4) Plans.

Numbers 1, 2 and 3 are drawn on Mercator's Projection and No. 4 on a plane projection.

11. **Measurement on a Chart.**—Every chart has two scales.

(a) A varying one for latitude and distance.
(b) A constant one for longitude.

The scale of latitude and distance will be found at the sides of the chart, and the scale of longitude at the top and bottom.

To find distance on a chart—

Lines parallel to the Meridians.—The length can be measured directly from the latitude scale. The difference in latitude of the extremities of the line expressed in minutes gives the length in nautical miles.

Lines parallel, or oblique to the Parallels of Latitude.—Suppose that it is required to measure an oblique line lying between latitudes 42°·00′ and 47°·00′. With dividers take from the latitude scale the distance between 44°·15′ and 44°·45′ (30 nautical miles), *i.e.*, at the mid-latitude of the line, and step this off along the line. If the line is longer than 500 nautical miles, it should be divided into sections and each section referred to its mid-latitude for a unit of measurement.

A unit of measurement of 30 minutes of latitude should not be exceeded, as the latitude scale is really only correct for any particular latitude at the point where that parallel cuts it. Consequently, if a larger unit of measurement is used, the measurement of the line will be subject to considerable error.

Latitude and longitude can be found or laid off on a chart with a parallel ruler, or a Douglas protractor.

12. **Reading a Chart.**—The key to the chart is the title; from this the locality covered, date of survey, abbreviations for lights and buoys, nature of sea bottom, soundings, tides, etc., will be found.

The date of the chart will be found on the bottom centre of the chart and in the bottom left-hand corner the dates, in Roman numerals, of any small corrections made since the chart was published. The coast-line and all channels at sea or in river-mouths are indicated by lighthouses, light-ships, or buoys, each of which shows a characteristic mark and light.

Characteristics of Lighthouses, etc.—In English waters all light vessels are painted red with the name clearly indicated on the hull in white letters. In Irish waters light vessels are painted black.

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All light vessels carry, in addition, a day or top mark, a description of which will be found in the Admiralty light lists.

Lighthouses are distinguished by various markings, such as a white tower with a black band half-way up, or a black tower with two white bands, etc.

These lights are just as useful to the air pilot as to the sea pilot, and in all cases where the nature of his duty takes the pilot over the sea or along the coast, use should be made of these distinctive points, just as of railways or rivers, when flying inland.

When piloting an aircraft by night, great assistance is given by the lights shown by lighthouses, etc., and beacons and aerial lighthouses are being erected on the principal air-routes, as additional guides to the night pilot.

Before starting on a flight a part or all of which will be over the coast or sea, the pilot should study the charts of the areas over which his course will take him and note, just as on the map, the lighthouses, etc., which will be passed en route, and the estimated times at which the aircraft should pass over them.

If the flight should be at night, the lights shown by the various lighthouses, etc., to be passed should be carefully noted, together with their relative importance. This may be deduced from the range or candle power.

All Admiralty charts can be set from one or other of the several compass roses printed on the surface.

A full explanation of all the signs on charts relating to lighthouses, light vessels, etc., and also all the different lights exhibited is given in the Admiralty Light List, and an explanation of the conventional signs used is given in the Admiralty Manual of Navigation.

It should be noted that an abbreviated form for the characteristics of lights is used on the International Aeronautical Maps.

Characteristic signs used on Admiralty charts are shown in Fig. 7.

13. **Field Sketch.**—The conventional signs and lettering used in Military Field Sketching are shown in Fig. 6.

14. MAGNETIC VARIATION, 1920.

UNITED KINGDOM.

London, Norwich	14° W.
Plymouth Liverpool, Newcastle	16° W.
Glasgow, Inverness	18° W.
Wexford, Dublin, Belfast	18° W.
Bantry, Galway, Donegal	19½° W.

(Decreasing 9½′–10′ annually.)

BRITISH DOMINIONS.

Canada.

St. Johns, Newfoundland	30° W.
Halifax	22½° W.
Quebec	19½° W.
Montreal	15° W.
Ottawa	13° W.
Toronto	6° W.
Winnipeg	13° E.
Calgary	25° E.
Esquimalt	24° E.

Australia.

Sydney	9½° E.
Brisbane	9° E.
Hobart	8½° E.
Melbourne	8° E.
Adelaide	5½° E.
Port Darwin	3½° E.
Coolgardie	1½° W.
Perth	5° W.

New Zealand.

Auckland	15° E.
Nelson	16° E.
Christchurch	17° E.
Invercargill	17½° E.

South Africa.

Cape Town	26° W.
Port Elizabeth	24° W.
Kimberley	22° W.
Walfish Bay	22° W.
Bloemfontein	21½° W.
Durban	20° W.
Mafeking	20° W.
Pretoria	19½° W.
Newcastle	19° W.
Bulawayo	15½° W.
Salisbury	13½° W.

Indian Empire.

Peshawar	4° E.
Karachi	1½° E.
Calcutta	0°
Bombay	½° W.
Rangoon	½° W.
Madras	1½° W.

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DAILY EXPRESS

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CURVES OF EQUAL MAGNETIC VARIATION, 1922.

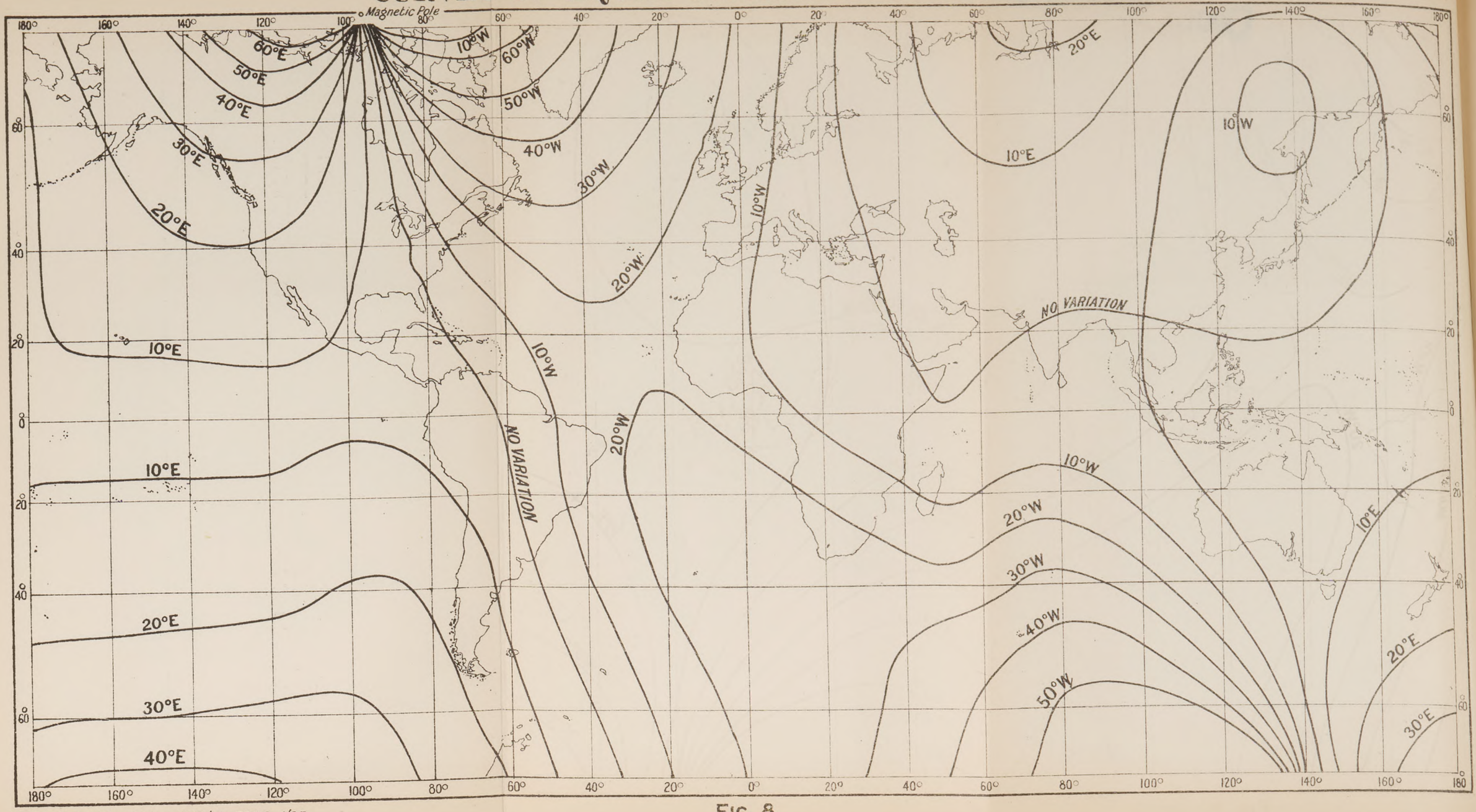

FIG. 8.

K504. H&Sp. G227. 298A. 10169/10. 7000. 1'25.

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BRITISH COLONIES, DEPENDENCIES, ETC., ETC.

Far East.

Wei-hai-wei	5° W.
Hong Kong	¼° W.
Suva (Fiji)	10¾° E.
Singapore	¼° E.
Colombo	2½° W.

Near East.

Baghdad	2¼° E.
Basra	2¾° E.
Aden	¼° E.
Jerusalem	0°

Mediterranean.

Cyprus (Larnaca)	0°
Malta	6¼° W.
Gibraltar	14° W.

Africa.

Cairo	1¼° W.
Khartoum	2¼° W.
Berbera	¼° E.
Mombasa	4¼° W.
Nairobi	4¾° W.
Entebbe	6° W.
Dar-es-Salaam	5° W.
Mauritius	9¼° W.
St. Helena	24° W.
Lagos	12¾° W.
Kano	9½° W.
Accra	14° W.
Sierra Leone (Freetown)	17¾° W.
Bathurst	18° W.

America.

Bermudas (Agar's I.)	12° W.
Kingston	1¼° E.
St. Kitts	5° W.
Bridgetown (Barbadoes)	5¼° W.
Port of Spain (Trinidad)	4° W.
Belize (Honduras)	5° E.
Georgetown (Gulana)	4¼° W.
Pt. Stanley (Falkland Is.)	9¼° E.

EUROPE.

Coimbra	15¼° W.
Paris	12¼° W.
Brussels	12° W.
Cologne	10½° W.
Venice	8° W.
Berlin	7½° W.
Rome	7° W.
Buda-Pest	5° W.
Warsaw	3¼° W.
Sofia	3½° W.
Salonica	3½° W.
Athens	3° W.
Constantinople	1° W.
Petrograd	3° E.
Baku	5° E.
Archangel	9° E.

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Chapter II.

7. DISCIPLINE.

PART I.—Powers of a Commanding Officer on active service.
PART II.—Field General Court Martial.
PART III.—Miscellaneous Instructions.

PART I.

POWERS OF A COMMANDING OFFICER ON ACTIVE SERVICE.

1. A C.O. can inflict the following punishment upon an airman below the status of an acting N.C.O. :—

(i) **Summary Punishments** (subject to the airman's right to claim Court Martial).

(a) *Detention* not exceeding 28 days.

Provided that (*a*) for the first offence of absence, not more than 168 hours' detention can be awarded, if the absence itself was for not more than 7 days.

If the C.O. is of rank of Flight Lieut. or below he cannot award more than 168 hours' detention, except in the case of absence without leave, when he may award 24 hours' detention for every day of absence up to a maximum of 28.

Note.—Detention may be legally awarded on active service, but its actual award must depend upon the possibility of Detention Barracks being available, and upon the general routine or other orders on this subject.

(b) (*On Active Service only.*) *Field Punishment* not exceeding 28 days. The award of Field Punishment depends upon general Routine or other orders, since detention may also be awarded on active service. The rules for field punishment are contained in Part III.

(c) (*On Active Service only.*) *Forfeiture of pay* for a period not exceeding 28 days.

This may be awarded either alone or in addition to any other punishment.

If awarded with Field Punishment or with detention, it is necessary (in order that the forfeiture of pay may be operative) that it shall exceed in period the sentence of Field Punishment or Detention by as many days as it is desired that the airman shall lose pay. Sentences commence on the day of the award, and Field Punishment or Detention themselves involve a forfeiture of pay. If, therefore, it is desired to sentence an airman to 10 days' forfeiture of pay in addition to Field Punishment for 14 days, the sentence of forfeiture of pay must be 24 days, since during the first 14 days of this sentence the airman's pay is already being forfeited by the Field Punishment.

(d) *Fines for Drunkenness* (*up to* £2).

In accordance with the following scale :—(K.R. 1125)

First Offence - -	5*s.*
Second ,, - -	10*s.*
Third ,, - -	15*s.*
Fourth ,, - -	£1
Subsequent Offences -	Not less than £1, or with sanction of higher authority, up to £2. On active service, fines for drunkenness cannot be awarded conjointly with Field Punishment, but may be awarded conjointly with forfeiture of pay under A.F.A. 46 (2) D. *Vide* A.F.A. Sect. 46 and footnotes thereto.

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(e) *Stoppages or Deductions from Pay* to make good damage or loss occasioned by negligence or wrongful act (S 138). In motor accidents these deductions should not, as a rule, exceed 14 days' pay. (K.R. 1124.)

(ii) Minor Punishments. (Not subject to any option of the airman to claim trial by Court Martial).

(*a*) Confinement to Camp not exceeding 14 days.
(*b*) Extra guards, or Piquets not exceeding three: for offences connected with such duty.
(*c*) Admonition.

2. Punishment of Non-Commissioned Officers.

Punishment that can be inflicted by Commanding Officers :—

(a) *With option of Court Martial.*
Stoppages to make good damage or losses occasioned by negligence or a wrongful act (S. 138).

(b) *Without option.*
Severe Reprimand.
Reprimand.
Admonition.

Note.—Acting N.C.O's., if reverted to permanent rank, may not also be reprimanded. No punishment, with the exception of stoppages for damage, may be given in addition. Cases which merit more punishment must be sent to Court Martial. (K.R. 1114.)

3. Powers of a Subordinate Commander.

Subordinate Commanders may be authorised by the Commanding Officer to administer the following punishments (K.R. 1092–1116) :—

(a) *With option of Court Martial.*
Fines for drunkenness on usual scale up to 15*s*. (K.R. 1125).
Automatic forfeiture of pay for absence under Royal Warrant.

(b) *Without option.*
Reprimand of Corporals (K.R. 1114).
Confinement to camp up to 7 days.
(If Subordinate Commander has less than 3 years' service, this power may be reduced to 3 days.)
Extra guards and piquets (as above).
Admonition.

4. Powers of a Detachment Commander. (K.R. 1112–13.)

If of rank of Squadron Leader a Detachment Commander has the full powers of a Commanding Officer unless specially restricted by higher authority.

If below rank of Squadron Leader he has the full powers of Commanding Officer; except that he may not award more than 7 days' detention save in cases of absence without leave, when he can award a day's detention for every day of absence up to 28. Note that he is under no such restriction as regards Field Punishment or Forfeiture of Pay.

Such powers may be restricted by higher authority, but may still be exercised subject to subsequent report in cases of necessity. They may be suspended altogether when two or more detachments are associated together, and where disciplinary powers over both are given to the Officer Commanding one of the detachments.

5. Award of two or more Punishments conjointly.

All the above punishments may be awarded together, subject to the following stipulations :—

No minor punishment may be added to a sentence of detention for over 7 days. Confinement to Camp added to Detention of 7 days or under commences to run when the detention is over.

On Active Service, fines for drunkenness cannot be awarded conjointly with Field Punishment. *Vide* A.F.A. Sect. 46.

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6. Cases that may be disposed of summarily by the Commanding Officer on Active Service without reference to Higher Authority :—

Section of Air Force Act.	Offence.
10 (2)	Assault of an Escort.
10 (3)	Resisting an Escort.
10 (4)	Breaking out of Camp.
11	Disobedience of standing orders.
14	Connivance at Desertion.
15	Absence without leave.
18	Malingering.
18	Aggravating Disease.
19	Drunkenness.
20	Permitting prisoner to escape.
21	Irregular arrest.
22	Escaping.
24	Deficiencies in equipment, etc.
27 (4)	False statement as to leave.
33 & 34	Offences relating to Enlistment.
40	Minor irregularities contrary to good order and Air Force Discipline.

Other offences must be submitted to Higher Authority, with the recommendation of the Commanding Officer (K.R. 1096–1097).

The Higher Authority will then :—

(*a*) give sanction for C.O. to deal with case : or

(*b*) convene a Court Martial.

Commanding Officers, in cases of extreme urgency, may deal with charges which they would otherwise refer to higher authority provided they immediately report their reasons for so doing to the higher authority to whom ordinarily they would have referred the cases (K.R. 1097).

PART 2.

FIELD GENERAL COURT MARTIAL.

7. When, on Active Service, *it is not practicable for an offence to be tried by an ordinary General or DISTRICT Court-Martial*, a Field General Court Martial may be convened (*see* Section 49 Air Force Act) by :—

(*a*) Any officer in immediate command of a body of the Air Force on active service.

(*b*) The Commanding Officer of any unit on active service.

(*Note.*—In special circumstances a Field General Court Martial may be convened not on active service, when beyond the seas and when the offence was committed against the property or person of an inhabitant of that country.)

8. Application for—

If a Commanding Officer decides that he will not dispose of a charge either because—

(1) He has no power to deal with that offence, or

(2) His powers of punishment are insufficient for the case, or

(3) The matter is one of importance that is best referred, or

(4) The accused has elected trial by Court Martial,

he will (if the conditions of active service render it possible) cause a Summary of Evidence to be taken down, comprising signed statements of the witnesses in support of the charge.

He will then forward to Higher Authority—

(1) This Summary of Evidence.

(2) Field Service Conduct Sheet (Form 122).

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(3) Suggested charge sheet.
(4) His own recommendations as to the case.

The accused meanwhile may be retained in open or close arrest, or may be released from arrest without prejudice to re-arrest when trial is arranged. If so released for his ordinary duties, the accused will receive pay for such days, whether he is subsequently convicted or not. If retained in close arrest he will forfeit all pay since the date of arrest, if subsequently convicted, but will lose no pay if acquitted.

9. Constitution of a Field General Court Martial.

Unless, having regard to the public service, it is impossible, the Court shall consist of (S 49 R.P. 106)!—

(1) Squadron Leader (or above) as President.
(2) Three members (or more) including the President (in any case not less than two).
(Members to be of more than 1 year's service.)

It is usual for an officer having special experience of Courts Martial to serve on the Court if one is available. He has the full powers of a member; he should take the record of the proceedings, and the President should follow his advice in all questions of law and procedure.

10. Convening of Court.

The following (which is page 1 of Form 3) gives the necessary order convening the court and provides for cases in which it is not possible to convene a court according to the qualifications laid down.

If Form 3 is not available, the following *pro forma* should be drawn up on plain paper, omitting paragraphs that are not required.

"On Active Service, this day of , 19 .

Whereas it appears to me, the undersigned, an officer in Command of , on active service, that the persons named in the Annexed Schedule, being subject to the Air Force Act, have committed the offences in the said Schedule mentioned

And whereas I am of opinion that it is not practicable that such offences should be tried by an ordinary General Court Martial; (and that it is not practicable to delay the trial for reference to a superior qualified Officer)

I hereby convene a Field General Court Martial to try the said persons, and to consist of the officers hereunder named.

I am unable to appoint:—
(1) Three Officers to form the Court.
(2) A Squadron Leader as President.
(3) Three Officers having more than one year's service).
for the following reasons, namely:—

President.

Rank.	Name.	Unit.

Members.

Rank.	Name.	Unit.

Signed _____
_____
Convening Officer."

11. The schedule referred to in the Convening Order above, which forms the backbone of the Proceedings of a Field General Court Martial, is found on p. 2 of Form 3. If Form 3 is not available the Schedule set out below should be ruled out on plain paper.

Columns A and B are filled up by convening officer before trial, who signs the Schedule at (F) below.

Columns C and D are filled up by the President of the Court who signs the Schedule at (G) below.

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Column E is filled up and signed by the confirming officer, who may be the convening officer or his superior.

Number, Rank, Name and Unit of Accused.	Offence charged.	Plea.	Finding, and if convicted, Sentence.	How dealt with by Confirming Officer.
A. (Example) No. 98742 A.C/2 Smith, J. No. 900 Squadron.	B. (Example) sec. 9 (2) When on active service disobeying a lawful command given by his superior officer, in that he, In the Field on 1.10.22 when ordered by F/O. C. E. Robinson No. 900 Squadron, his superior officer, to report back to camp immediately, did not do so.	C. (Example) Not guilty. (or another example). Guilty.	D. (Example) Guilty, 60 days F.P. (or) Not guilty Accused Released. (or another example). Guilty. 14 days F.P. and to forfeit 28 days' Pay.	E. (Example) Confirmed (or another Example). Finding and sentence confirmed, but Forfeiture of Pay remitted. (or another Example). Not Confirmed. A. B. Group Captain Confirming Officer.

(Signed).....(F.).....(Signed) .....(G).....
Convening Officer. President.

Sentences should be framed as laid down in K.R. 1272.

12. A short record of the evidence of the witnesses should be kept and attached to the Schedule.

13. The President in addition to filling up and signing columns C and D of the schedule should attach the following Certificate:—

"I certify that the above Court assembled on the day of and duly tried the persons named in the said Schedule, and that the plea, finding, and sentence in the case of each such person were as, stated in the third and fourth columns of that Schedule.

I also certify that

1. The members of the Court
2. The witnesses
3. The interpreter)
4. The officers under instructions).

were duly sworn.

Signed this day of 19 .
President of the Court Martial."

14. The Confirming Officer (who may be either the convening officer or his superior) in addition to filling up column E. of the Schedule should attach the following certificate:—

"I have dealt with the findings and sentences in the manner stated in the last column of the said Schedule, and, subject to what I have there stated, I hereby confirm the above findings and sentences.

Signed this day of 19 .

Confirming Officer."

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The Confirming Officer may also direct that the accused shall not be committed to prison to undergo his sentence until further orders, in order that the question of suspending the sentence (under S. 57A) may be considered.

15. Sentences that may be passed by Field General Courts Martial. (provided that the Section under which the charge is framed, permits).

Officers.	N.C.Os.	Airmen.
Death.	Death.	Death.
Penal Servitude (for not less than 3 years).	Penal Servitude (for not less than 3 years).	Penal Servitude (for not less than 3 years).
Imprisonment (with hard labour) (for not more than 2 years).	Imprisonment (with hard labour) (for not more than 2 years).	Imprisonment (with hard labour) (for not more than 2 years).
Imprisonment (without hard labour) (for not more than 2 years).	Imprisonment (without hard labour) (for not more than 2 years).	Imprisonment (without hard labour) (for not more than 2 years).
	DETENTION not exceeding 2 years.	*DETENTION not exceeding 2 years.*
Cashiering.	Field Punishment. Not exceeding 3 months.	Field Punishment. Not exceeding 3 months.
Dismissal from H.M.'s Service.		
Forfeiture of Seniority (*a*) Rank to date from—	Forfeiture of Pay. Not exceeding 3 months.	Forfeiture of Pay. Not exceeding 3 months.
(*b*) So many places lower in Air Force List.	Stoppages of pay for damage.	Stoppages of Pay for damage.
Severe Reprimand.	Discharge with Ignominy.	Discharge with Ignominy.
Reprimand.	Reduction to a lower grade or to the Ranks.	
	Forfeiture of Seniority.	*Note.*—*See* S.44 A.F.A. Also K.R. 1269.
	Severe Reprimand.	
	Reprimand.	

16. Charges on Active Service likely to occur.

Offence.	Section of A.F.A.	Maximum Punishment. (On active service).
Absence without leave - -	15	2 years' imprisonment.
Alarm and despondency—spreading.	5 (6)	Penal servitude.
Breaking out of camp - -	10 (4)	2 years' imprisonment.
" standing orders -	11	2 years' imprisonment.
Civil offences - - -	41	Appropriate civil punishment.
Cowardice - - - -	4 (7)	Death.
Desertion - - - -	12	Death.
Disobeying in such a manner as to show a wilful defiance of authority or disobeying any lawful command.	9 (1)	Death.

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Offence.	Section of A.F.A.	Maximum Punishment. (On active service).
Documents (falsifying)	25	2 years' imprisonment.
Drunkenness	19	2 years' imprisonment.
Escaping	22	2 years' imprisonment.
Escape, allowing prisoners to	20	Penal servitude if wilful; 2 years' imprisonment if not.
Fraud	18 (5)	2 years' imprisonment.
Good order and Air Force Discipline (conduct prejudicial to).	40	2 years' imprisonment.
Indecency	18 (5)	2 years' imprisonment.
Inhabitants—offences against	6 (i) (f)	Death.
Injuring public property	24 (4)	2 years' imprisonment.
Insubordinate language	8	Penal servitude.
Looting	6 (i) (g)	Death.
Losing by neglect	24 (2)	2 years' imprisonment.
Maiming	18 (2)	2 years' imprisonment.
Making away with kit	24 (1)	2 years' imprisonment.
Malingering	18	2 years' imprisonment.
Mutiny	7	Death.
Scandalous conduct (officers)	16	Cashiering.
Post leaving	6 (i) (b)	Death.
,, delivering up	4	Death.
Plunder, breaking into house for.	6 (i) (g)	Death.
Refusing to obey (*see* Disobeying).		
Resisting an escort	10 (3)	2 years' imprisonment.
Sentry—sleeping or drunk	6 (i) (K) (i)	Death.
,, Leaving his post	6 (i) (K) (2)	Death.
,, Forcing a	6 (i) (d)	Death.
Shamefully leaving post, etc.	4	Death.
Stealing under Civil Law	41	Appropriate Civil punishment.
,, public property	17 & 18	Penal servitude (17).
,, property of comrade	18	2 years' imprisonment.
,, Service property	17 & 18	Penal servitude (17).
Striking a superior officer	8	Death.
,, an airman	37	2 years' imprisonment.
Threatening a superior officer	8 (2)	Penal servitude.
Violence to a superior officer	8	Death.

17. **Specimen Charges.**

(*a*) S. 12 - *Desertion.* - When on active service deserting H.M. Service in that he in the field absented himself from his Squadron at..... hours on.....19 until apprehended by the civil power at.....on.....

(*b*) S. 15 - *Absence without Leave.* - When on active service absenting himself without leave in that he In the Field absented himself without leave from..... hours on.....19 until.....hours .....19 .

(*c*) S. 19 - *Drunkenness.* - When on active service Drunkenness in that he on the Field on.....19 was drunk.

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(*d*) S. 9 (2) - *Disobeying an order.* - When on active service disobeying a lawful command given by his superior officer
in that he
In the Field on.....19 when ordered by Flight Sergt..... his superior officer to.....did not do so.

(*e*) S. 40 - *Hesitating to obey an order.* - When on active service conduct to the prejudice of good order and Air Force Discipline
in that he
In the Field on.....19 when ordered by Flying Officer.....to immediately..... hesitated and took unnecessary time before obeying the said order.

(*f*) S. 11 - *Disobedience of Standing Orders.* - When on active service neglecting to obey Camp orders
in that he
In the Field on.....19 bathed in the River.....above the camp contrary to Camp Order dated.....which directed that no airman should bathe in that part of the river.

(*g*) S. 8 (2) - *Striking a superior officer.* - When on active service striking his superior officer
in that he
In the Field on.....19 struck in the face with his fist Flight Sergeant.....his superior officer.

(*h*) S. 8 (2) - *Insubordinate language.* - When on active service, using insubordinate language to his superior officer
in that he
In the Field on.....19 when ordered by Flight Sergeant.....his superior officer to make less noise, replied, " Who the devil cares what you say," or words to that effect.

(*i*) S. 18 (4) *Stealing from a Comrade.* - When on active service stealing goods the property of a comrade
in that he
In the Field on.....19 stole a wrist watch the property of.....an airman of the same Squadron.

(*j*) S. 6 (l) (k) *Sentry sleeping on his post.* - When an airman acting as sentinel on active service sleeping on his post,
in that he
In the Field on.....19 between..... .....hours and.....hours when sentry on No..... Post.....guard was asleep.

(*k*) S. 40 - *Conduct to the Prejudice of good order.* - When on active service conduct to the prejudice of good order and Air Force Discipline
in that he
In the Field on.....19 .....etc.
(May be used for any small offence, really prejudicial to good order and discipline, *which does not fall under a separate section of the Act.*)

PART 3.

MISCELLANEOUS INSTRUCTIONS.

A. Royal Navy, Military Forces and R.A.F. Operating Together.

18. **Naval or Military Officers may sit as President or Members of an Air Force Court Martial.**—In a place where the necessary number of Air Force officers is not available to form a Court Martial, the convening officer may (with the consent of the naval and military authorities) nominate naval or army officers to act as President or sit as members of an Air Force Court Martial. (Section 48 (10)).

In such case, an opinion must be recorded on the order convening the Court, either that the necessary number of R.A.F. Officers is not available to form the Court, or that they could not be made available without

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serious injury to the interests of the Service. The Naval or Military Officers appointed must be of proper equivalent rank.

19. **For the purpose of Command and Discipline.** (*Section 184A.*)—The effect of the joint application of the provisions of Section 184A. of the Army Act, and Section 184A. of the Air Force Act, or of Section 90A. of the Naval Discipline Act is to render more perfect the co-operation between the Navy and the R.A.F., or the Army and the R.A.F., when they are working together. The co-operation can be made more effective when command and discipline can be exercised by a senior over a junior in rank, even though the latter may be in another service. Under certain conditions therefore superior officers can legally exercise their powers of command and discipline outside their own service over bodies acting in conjunction with them; but cannot punish except an accused is temporarily serving under the same Act as the superior officer under a direction of attachment. (Sec. 179A.).

20. A joint declaration by the Army and the Air Force applies to Sections 184A. of the Army and of the Air Force Acts, when any of the following conditions are complied with:—

(i) When an order has been made by the Army and Air Force applying the Sections in the case of:—

(*a*) bodies of Army and Air Force acting together and belonging to an expeditionary force beyond the seas, except that no power of punishment is given to members of one body over members of the other body, who must be punished by members of their own service.

(*b*) bodies of Army and Air Force together on a transport or troopship, except that the power of punishment can only be applied by military officers when there are no officers of the R.A.F. on board in which case the R.A.F. details are regarded as if they were attached.

(ii) In case of emergency where two forces are acting together and reference to the Army Council or Air Ministry would cause undue delay, an order in writing applying the sections referred to may be made by the officers commanding the two forces respectively; but in each case such officers should communicate the fact to the Army Council and Air Council.

(iii) *By declaration*, it has been declared that:—

(*a*) Whenever any body of the military police is acting in any place where there is any body of His Majesty's Air Force, then, for the purpose of command and discipline, and for the purpose of the provisions of the Air Force Act relating to superior officers, all Military Police ranks shall be treated as if they were Air Force ranks except with regard to punishment.

(*b*) Similar provision as regards any body of the R.A.F. service police acting in any place where there is any body of His Majesty's military forces.

(*c*) Whenever any Air Force prisoners or airmen undergoing detention are committed to any prison or detention barracks, of which the Governor, Commandant, officers or staff are officers, warrant officers or non-commissioned officers of a body of His Majesty's military forces, then for the purpose of command and discipline, and for the purposes of the provisions of the Air Force Act relating to superior officers, such above military ranks shall during the time that Air Force prisoners are undergoing imprisonment or detention be treated as Air Force ranks except with regard to punishment. But nothing shall derogate from them any powers of punishment which military ranks have by virtue of rules made pursuant to Section 133 of the Air Force Act or Section 133 of the Army Act. (There is a similar provision applying to military prisoners or soldiers undergoing detention in Air Force prisons or detention barracks).

21. The Admiralty and Air Council have a condition similar to (ii) above and have made a joint declaration applying Sect. 90A. N.D.A. and Sect. 184A. A.F.A. in the following circumstances:—

(1) Similar to (iii) (*a*) and (*b*) in preceding paragraph.

(2) Whenever any British naval and air forces are operating together outside the British Isles.

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(3) When members or bodies of the Navy, not being subject to the Air Force Act, are attached or lent to the R.A.F.; or when members or bodies of the Air Force, not being subject to the Naval Discipline Act, are attached or lent to the Navy.

The above orders apply only to ranks not below that of Petty Officer or Sergeant respectively.

B. ATTACHMENTS.

22. Officers and soldiers of the Army and officers and airmen of the Air Force may be attached to the other service by directions given from time to time by each service with approval of Army and Air Councils.

Directions have been given by the Air Council that Section 179A shall apply in the circumstances set forth below. When applied the effect is that each individual of the one service so attached comes forthwith under the complete discipline of the other service with a proviso that a General Court Martial shall be confirmed by the parent service unless there is, overseas, no officer authorised to confirm the findings and sentences of General Courts Martial. This opinion must be stated in the confirmation, which may be made by the officer who holds the required warrant.

Directions:—Section 179A applies in the following cases:—

(i) When any officer or airman of the regular Air Force is instructed to serve with a unit of the Regular (Military) Forces and is taken on the strength of that unit (a provision similar to the above makes officers and soldiers of the military forces subject to the Air Force Act when attached to the R.A.F.).

(ii) When an airman of the regular Air Force is on board a military transport or troopship where there is no R.A.F. Officer on board or no naval or military officer attached to the regular Air Force; in which case the airman is temporarily attached to the military forces whilst on board.

C. FIELD PUNISHMENT.

RULES FOR FIELD PUNISHMENT MADE UNDER SECTION 44, AIR FORCE ACT.

23. A court martial, or a C.O., may award field punishment for any offence committed on active service, and may sentence an offender to such punishment for a period not exceeing in the case of a court martial three months, and in the case of a C.O. 28 days.

Where an offender is sentenced to field punishment he may, during the continuance of his sentence, unless the court martial or the C.O. otherwise directs, be punished as follows:—

(*a*) He may be kept in irons, *i.e.*, in fetters or handcuffs, or both fetters and handcuffs; and may be secured so as to prevent his escape.

(*b*) Straps or ropes may be used for the purpose of these rules in lieu of irons.

(*c*) He may be subjected to the like labour, employment, and restraint, and dealt with in like manner as if he were under sentence of imprisonment with hard labour.

Every portion of a field punishment shall be inflicted in such a manner as is calculated not to cause injury or to leave any permanent mark on the offender; and a portion of a field punishment must be discontinued upon a report by a responsible medical officer that the continuance of that portion would be prejudicial to the offender's health.

Field punishment will be carried out in the unit, when the unit to which the offender belongs or is attached is actually on the move, but when the unit is halted at any place where there is a provost marshal, or an assistant provost marshal, the punishment will be carried out under that officer.

When the unit to which an offender under sentence of field punishment belongs or is attached is actually on the move, such offender shall march with his unit, carry his arms and accoutrements, perform all his air force duties as well as extra fatigue duties, and be treated as a defaulter.

D. PROVOST MARSHAL.

24. A Provost Marshal is appointed for the prompt repression of offences by order of the Air Council or by an Air Officer Commanding *vide* Sect. 74

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A.F.A. He and his assistants, including any service police actually and directly exercising their authority under his orders or on his behalf, may at any time arrest and detain for trial persons subject to Air Force law committing offences, and may arrest and hand over for trial persons declared subject to command and discipline for the time being by the other services. They may also carry into execution any punishments to be inflicted in pursuance of a sentence by Court Martial, or by summary award; but shall not inflict any punishment on their own authority, except that they have the same powers as the governor of an Air Force prison respecting any airman in their custody undergoing field punishment.

E. R.A.F. Service Police.

25. Service Police are airmen on temporary police duty employed either to maintain order within the vicinity of their own units or to quell disturbances outside the immediate precincts of their units. They are normally under the orders of the camp adjutant, or may be placed specially under the orders of a Provost Marshal, a Governor of a prison, or a commandant of a detention barracks for particular duties prescribed by orders or instructions.

F. Arrest and Custody.

26. Air Force custody as applied to persons charged with an offence means placing an offender under arrest or putting him into confinement and includes naval and military custody.

An officer or N.C.O. placing a person into custody of a guard, piquet, patrol, sentry, or of a Provost Marshal, must as soon as practicable and in every case within 24 hours deliver in writing signed by himself an account of the offence. The officer or N.C.O. into whose custody the accused is committed must give in writing to the officer to whom he may be ordered to report the name and offence of the accused as far as is known to him, and the name and rank of the person by whom charged. The report must be made in any case within 24 hours. It must be accompanied by the charge if he has received it.

An offender belonging to another service who may have been apprehended by Air Force authorities must be dealt with for the offence by his own service, and must be handed over without delay to his superior officer having power to deal with his offence. A charge is to be made out and if necessary evidence must be made available.

If he has not received the charge, the commander of a guard or a Provost Marshal must mention the circumstances in his report; if the charge is not delivered within 24 hours he must make a further report to his superior officer, who, if evidence sufficient to justify retention of accused in custody is not forthcoming, will at the expiration of 48 hours from the time of committal order him to be released without prejudice to re-arrest. A C.O. who has received the report of the committal of an accused becomes responsible for having the case investigated without delay, *i.e.*, within 48 hours.

Arrest may be close or open.

Officers in close arrest are confined to quarters or tent, provided that exercise under directions of the M.O. may be permitted outside under supervision.

An officer in open arrest enjoys greater freedom at the discretion of the C.O., but is not to use his own or any other Mess premises or appear in any place of amusement or entertainment or public assembly, and is never to appear outside his tent or quarter dressed otherwise than in uniform. An officer should only be released from arrest with the sanction of the highest authority to whom the case has been referred. An airman in close arrest will be placed in charge of a guard, piquet, sentry or Provost Marshal; in open arrest he will stop in camp, but attend parades.

An offender in arrest on active service may be ordered to bear arms, attend parade, and perform all ordinary duties provided that care is taken to ensure that he is not called upon to perform duties in addition to those performed by airmen who are not in arrest.

G. Imprisonment and Detention.

27. In any country in which operations against the enemy are being conducted, the powers of a Secretary of State under Section 133 (2) shall

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be exercisable by the Commander-in-Chief in the field, and shall include the power of declaring any place to be a military prison or a detention barrack. Limitations in the power of making rules as to the punishment of prisoners and airmen undergoing detention and as to severity of punishment shall not apply, except that corporal punishment cannot be inflicted. Section 133 (7), and in the case of field punishment, a prisoner cannot be attached to a fixed object.

A Secretary of State, or in India the Governor General, can set apart any building or part of a building under the control of a Secretary of State, or of the Governor General, as an Air Force prison or Detention Barrack. Any military prison or detention barrack shall unless the Secretary of State otherwise direct be deemed to be an Air Force prison or detention barrack within the meaning of Section 133, Air Force Act.

An Air Force prisoner may undergo the term of his sentence of imprisonment either in an Air Force prison or in a detention barrack or in other Air Force custody or in a civil prison or partly in one way and partly in another; but an accused ordered to undergo detention cannot be placed in a prison.

An Air Force prisoner or airman under sentence of detention, who was sentenced in a foreign country, will undergo sentence in that foreign country or in any foreign country in which the force with which he is serving may be, or in the United Kingdom, or such other place as may be prescribed.

An Air Force prisoner or airman under sentence of detention, who was sentenced in India or a colony, shall undergo his sentence either in India or in that colony (as the case may be), or in such other part of His Majesty's Dominions as may be prescribed, or in the United Kingdom.

Provided that :—

If term of sentence is over 12 months he shall be transferred as soon as practicable to a prison or detention barrack in the United Kingdom, unless :—

(i) The court orders otherwise for special reasons, or

(ii) It would be unbeneficial to the prisoner himself to so transfer him.

An Air Force prisoner in India or a colony shall not, for longer than is absolutely necessary, be detained in any civil prison other than a prison in respect of which arrangements have been made by a Secretary of State under the Air Force Act, or by the Governor General of India, or Governor of the colony.

H. LEGAL DEFINITIONS.

28. (i) The expression "Air Force convict" means a person under sentence of penal servitude passed by a Court Martial.

(ii) The expression "Air Force prisoner" means a person under sentence of imprisonment passed by a Court Martial.

(iii) The expression "civil custody" means the custody of the police or other lawful civil authority authorised to retain in custody civil prisoners, and includes confinement in a civil prison.

(iv) The expression "civil prison" means any prison in the United Kingdom in which offenders sentenced by a civil court to imprisonment can for the time being be confined, and any prison in India or a colony in which European offenders so sentenced can for the time being be confined.

(v) The expression "penal servitude prison" means any prison or place in which a person sentenced to penal servitude by a civil court in the United Kingdom can for the time being be confined either permanently or temporarily, and any prison or place in India or a colony in which persons sentenced to penal servitude by a civil court in India or the colony can for the time being be confined. Provided that where there is no such prison or place in a colony the expression "penal servitude prison" shall, in that colony, mean a civil prison.

8. SYSTEM OF SUPPLY IN THE FIELD.

1. The R.A.F. is responsible for the supply of :—

(*a*) All technical stores and equipment.

(*b*) Aviation Petrol and Oil.

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(*c*) R.A.F. clothing.
(*d*) Special machine-gun ammunition.
(*e*) Camp equipment.
(*f*) Tentage.

It is possible, however, that in certain types of operations, after the initial stage has been passed, the supply of (*b*), (*e*) and (*f*) may, by arrangement, be supplied through Army channels.

2. The Army supplies the following :—

Royal Army Service Corps -	(*a*) Rations. (*b*) M.T. Petrol and Oil.
Royal Army Ordnance - -	(*a*) Ordinary ·303 Ammunition. (*b*) Revolver ammunition. (*c*) Bombs.

(*Note.*—The R.A.F. will shortly take over the supply of bombs.)

Royal Engineers - - Hutting, bridging, roadmaking materials, etc.

3. The following are the types and functions of R.A.F. Stores Supply Units :—

(a) *Advanced Aircraft Park.*—An Advanced Aircraft Park is a mobile unit which acts as an intermediary between Squadrons and the Aircraft Depôt. It usually holds about one to three months' supply of stores according to circumstances, and does not carry out repairs other than repairs to aircraft.

(b) *Aircraft Depôt.*—An Aircraft Depôt is an immobile unit normally holding three to six months' supply of stores according to circumstances, and may include :—

(i) Aeroplane Repair Section.
(ii) Engine Repair Section.
(iii) M.T. Repair Section.
(iv) Receipt and Issue Section.

(c) *Port Depôt.*—The functions of a Port Depôt are to unload equipment at the port of disembarkation and to act as a forwarding agency. It is usually a detachment of an Aircraft Depôt. The Port Depôt is often combined with the Embarkation Staff dealing with movements of personnel.

These units are subject to alteration as the situation demands.

9. FIELD KITS.

(NOT APPLICABLE TO INDIA.)

TABLE A.

Officers.

Detail.	No.	Approximate Weight.		Remarks.
		Lbs.	Ozs.	
A.—*Clothing worn by the Officer :*				
(i) *On Ground Duty.*				
*Boots, lace, pairs - - -	1	2	5	* Squadron Leaders and above wear "Boots, field," which will add about 1 lb. 6 ozs. to the weight of the clothing.
Braces, pair - - -	1	—	4	
Cap, service dress, with badge	1	—	8	
Disc, identity, with cord -	1	—	0½	
Puttees, pair - - -	1	—	13	
Socks pairs - - -	1	—	4	
Suit, service dress - -	1	4	9	
Underclothing, suit - -	1	3	0	
Total A (1) -	—	11	11½	

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Detail.	No.	Approximate Weight. Lbs.	Approximate Weight. Ozs.	Remarks.
(ii) *Flying.* When flying the Officer would wear all items on (i) less the "boots, lace" weight 2 lbs. 5 ozs. and service dress cap, weight 8 ozs., plus the following special flying clothing :—				
Suit, aviation	1	9	4½	
Cap, fur-lined	1	—	6¾	
Gauntlets, pilots and observers, pairs	1	—	9½	
Linings, worsted, for gauntlets, pair	1	—	1½	
Gloves, silk, pairs	1	—	¾	
Boots, flying, thigh, pairs	1	8	9	
Goggles, mask (with glasses tinted and non-tinted, pairs	1	—	4½	
Total (ii)		19	4	
Extra for pilots and observers operating over water :—				
Belt, life-saving, Perrin pattern	1	1	8½	
B.—*Other personal effects carried by the Officer.*				
Books :—				
A.B. 153	1	—	10	
Field Service Pocket Book	1	—	3	
Compass, magnetic, pocket (prismatic) in case	1	—	4	
Dressing, field	1	—	2	
Glasses, binocular, in case	1	2	0	
Greatcoat	1	6	9	
Handkerchief	1	—	2	
Knife, clasp	1	—	6	
Watch, luminous	1	—	2	
Whistle and lanyard	1	—	2½	
Map case	1	—	—	
Total (B)	—	10	8½	
C.—*Accoutrements :*				
Haversack	1	—	11	
Mess tin	1	1	9	
Water bottle and sling	1	—	14	
Bag, ration	1	—	0½	
Total (C)	—	3	2½	
D.—*Arms :*				
Pistol, Colt, Auto, ·455	1	2	5½	

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Detail.	No.	Approximate Weight. lbs.	ozs.	Remarks.
E.—*Ammunition:*				
Cartridges, S.A. ball, ·455 Pistol, S.L. - - - -	14	—	10	
F.—*Rations and Water:*				
Bread ration, unconsumed portion, say - - - - - -		—	12	
Cheese - - - - -		—	3	
Iron Ration—				
Biscuit - - - - -		1	0	
Preserved meat (nominal) - -		1	0	
Tea, ½ oz. } in a tin - -		—	5	
Sugar, 2 ozs. }				
Water (2¼ pints) - - -		2	13	
Total (F) - -		6	1	
Total Weight carried on the Person:				
*A.—Clothing worn on ground duties		11	11½	* When flying the weight of clothing worn under A above is :—31 lbs. 7 ozs., or 32 lbs. 15½ ozs. when life-saving belt is worn.
B.—Other personal effects - -		10	8½	
C.—Accoutrements - - -		3	2½	
D.—Arms - - - - -		2	5½	
E.—Ammunition - - -		—	10	
F.—Rations and water - -		6	1	
Total Carried - -		34	7	
CARRIED IN UNITS TRANSPORT.				
Boots, gum, pairs - - -	1	3	10	
Boots, lace, pairs - - -	1	2	11	
Bucket, canvas - - -	1	1	4	
Cap comforter - - -	1	—	4	
Cardigan - - - -	1	2	1	
Grease or vaseline - - -	1	—	2	
Handkerchiefs - - -	5	—	6	
Holdall, containing hairbrush and comb, tooth brush, shaving brush and razor - -	1	1	0	
Housewife - - - -	1	—	4	
Lantern, collapsible - -	1	—	8	
Puttees, pair - - -	1	—	13	
Portfolio, with writing materials	1	1	0	
Shoes, canvas, pair - - -	1	1	5	
Soap, piece - - - -	1	—	3	
Socks, pairs - - - -	2	—	8	
Suit, service dress - - -	1	4	13	
Torch and refill - - -	1	—	5	
Towels - - - - -	2	1	10	
Underclothing, suit - -	1	3	0	
Valise (Wolseley) or other pattern - - - - -	1	11	3	
(Total) Minimum -	—	36	14	The weight of these articles is not included in the 50 or 35 lbs. allowed to each officer.
Maximum -	—	40	0	

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Airmen. TABLE B.

Detail.	No.	Approximate Weight. Lbs.	Ozs.	Remarks.
A.—*Clothing, etc., worn by each airman.*				
Boots, ankle, pair	1	3	14	
Braces, pair	1	—	4½	
Cap, service dress with badge	1	—	6	
Disc, identity, with cord	2	—	0½	
Drawers, woollen, pair	1	1	1	
Jacket, service dress, with field dressing	1	2	9	
Knife, clasp, with lanyard	1	—	7½	
Pay book (in right breast pocket of S.D. jacket)	1	0	2	
Puttees, pair	1	0	13	
Shirt	1	1	1½	
Socks, worsted, pair	1	—	4½	
*Collar	1	—	(1)	* Sergeants and above only.
*Pins, tie	1	—	(½)	
*Tie	1	—	(1)	
Pantaloons, service dress, prs.	1	1	15	
Waistcoat, cardigan	1	1	6	
Total A	—	14	4½	

Note.—"Suits, combination," 2 pairs will be carried on Units transport for all ranks entitled, also 1 pair of canvas shoes per airman employed on aircraft.

When flying, all ranks wear flying clothing as for Officers.

B.—*Arms:*	No.	Lbs.	Ozs.
Sergeants and above (except medical personnel)—			
Magazines for	2	—	8
Pistol, Colt, auto. ·455	1	2	5½
Pistol, Revolver, Webley, Mk. VI. (all ranks Arm. Car Coys.)	1	2	6
Ranks below Sergeant (except medical personnel)—			
Rifle, with oil bottle, pull-through	1	8	15½
Bayonet and scabbard	1	1	8½

Total, B.—2 lbs. 5½ ozs. for Sergeants and above, and 10 lbs. 8 ozs. for ranks below Sergeant.

C.—*Ammunition:*			
Sergeants and above (except medical personnel)—			
Cartridges S.A. ball ·455 pistol S.L.	14	—	10
Ranks below Sergeant (except medical personnel)—			
Cartridges, S.A. ·303"	50	3	0
Cartridges, .455, Revolver, Mk. II. (all ranks Arm. Car Coys.	12	—	9½

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	No.	W.O. Class I.		W.O. Class II. Flight Sergeants and Sergeants, except R.A.F. Medical.		Corporals and Aircraftsmen. except Arm. Car Coys. and R.A.F. Medical.		Corporals and Aircraftsmen. Armoured Car Coys.		R.A.F. Medical all Airmen.		Remarks.
D.—*Accoutrements:*		Lbs.	Ozs.	Lbs.	Ozs.	Lbs.	Ozs.	Lbs.	Ozs.	Lbs.	Ozs.	
Bag, ration	1	–	0½	–	0½	–	0½	–	0½	–	0½	
Bottle, water	1	–	15	–	15	–	15	–	15	–	15	
Carrier, water bottle	1	–	6	–	6	–	6	–	6	–	6	
Cases, pistol, Webley, with brass hooks	1	–	7½	–	7½	–	–	–	7½	–	–	
Lanyards, pistol	1	–	1	–	1	–	–	–	1	–	–	
Pouches, ammunition, pistol	1	–	3½	–	3½	–	–	–	3½	–	–	
Tins, mess	1	1	3	1	3	1	3	–	3	1	3	
Straps, mess tin	1	–	2½	–	2½	–	2½	–	2½	–	2½	* And to W.O. Class I. R.A.F. Medical.
*Whistles, infantry	1	–	1½	–	–	–	–	–	–	–	–	
Attachments, brace	2	–	11	–	11	–	–	–	11	–	11	
Belts, waist	1	–	14	–	14	–	14	–	14	–	14	
Braces, with buckles	2	–	–	–	12	–	12	–	12	–	12	
Braces, without buckles	2	–	10	–	–	–	–	–	–	–	–	
Carriers, cartridge, left, 75 rounds	1	–	–	–	–	1	0	–	–	–	–	
Carriers, cartridge, right, 75 rounds	1	–	–	–	–	1	0	–	–	–	–	
Frog	1	–	–	–	–	–	3	–	–	–	–	
*Haversack	1	1	2	1	2	1	2	1	2	1	2	
Pack	1	–	–	1	8	1	8	1	8	1	8	
Sling, rifle, web	1	–	–	–	–	–	4	–	–	–	–	
Straps, supporting	2	–	–	–	4	–	4	–	4	–	4	
Totals	—	6	13½	8	10	9	10	8	10	7	14	

* Knife (2¾ ozs.), fork and spoon (1¾ ozs.) carried in haversack, not shown in weight above.

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Detail.	No.	Approximate Weight.		Remarks.
E.—*Articles carried in the Pack :*		Lbs.	Ozs.	
Holdall (4 ozs.) containing laces (½ oz.) toothbrush (1 oz.), razor and case (3 oz.) shaving brush (1 oz.) and comb (1 oz.)	1	—	10¼	
Cap comforter	1	—	4	
Gloves, worsted, pair	1	—	2½	
Greatcoat	1	5	9½	
Housewife	1	—	3½	
Mess tin and cover	1	1	6½	
Socks, worsted, pair	1	—	4¼	
Soap, piece	1	—	3	
Towel, hand	1	—	9	
Total (E)	—	9	4½	
F.—*Rations and Water :*		Lbs.	Ozs.	
Bread ration, unconsumed portion say		—	12	
Cheese		—	3	
Iron ration—				
Biscuit		1	0	
Preserved meat (nominal)		1	0	
Tea, ½ oz. Sugar, 2 ozs. } in a tin		—	5	
Water (2 pints)		2	8	
Total (F)		5	12	
Total weight carried :				
A.—Clothing worn (ground duties)	*14		4½	*When flying, all ranks wear flying-clothing as for officers.
Sergeants and ranks above	(2		5½)	
B.—Arms, ranks below sergeant	10		8	
Sergeants and ranks above	—		(10)	
C.—Ammunition, ranks below sergeant	3		0	
D.—Accoutrements—				
W.O. Class I.	(6		13½)	
W.O.'s. Class II., Flight Sergeants and Sergeants	(8		10)	* Armoured Car Coys. = 8 lbs. 10 ozs. R.A.F. Medical Branch = 7 lbs. 14 oz.
*Ranks below sergeant	9		10	
E.—Articles in pack	9		4½	
F.—Rations and water	5		12	
Total, ground duties, ranks below sergeant	52		6¾	

MARCHING ORDER WITHOUT PACKS.

The above arrangements allow of the airman having normally with him the whole of his equipment; but in certain circumstances the commander

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may decide to increase the amount of S.A.A. carried on the person, and to discard temporarily certain articles of equipment, *e.g.*, pack and contents.

	Lbs.	Ozs.
Marching order (as above)	52	6¼
Deduct pack and contents (E)	10	10
	41	12¼
Add 100 rounds S.A.A. in two 50-round cotton bandoliers	6	2
Total "fighting equipment" (without pack but with 150 rounds S.A.A.)	47	14¼

ARTICLES LEFT AT THE BASE FOR EACH AIRMAN.

Kitbags containing the spare kit detailed below will be handed over to the Officer Commanding, Base Details, for retention at the Base Depôt to be forwarded only as may be deemed convenient to the service by the Commander in Chief, or A.O.C., as the case may be.

Articles.	No.	Articles.	No.
Clothing.		*Necessaries.*	
Boots, ankle, pair	1	Brush, hair	1
Drawers, pair	1	Cane, regulation	1
Jacket, service dress	1	Shirt, flannel	1
Shoes, canvas, pair	1	Socks, worsted, pair	1
Trousers, service dress, pair	1	Towel, hand	1

10. BILLETS.

1. In allotting areas, units should be kept together under their own commanders as far as possible.

2. In the absence of data as to the capacity of an area, ordinary billets with subsistence should be possible for a force about twice the population for one week. Billets without subsistence can be provided at the rate of about 10 men per inhabitant in rich agricultural districts, and at the rate of about 5–6 men per inhabitant in town or industrial districts.

3. When time permits, billeting demands (*see* p. 49) are issued to representatives of units by Area or Group Commanders. Unit representatives accompanied by a billeting party, consisting of an officer or non-commissioned officer and one airman per Squadron or Company, proceeds to the mayor or equivalent official in the Area, presents the Billeting Demand, and obtains a billeting order (*see* p. 49) for each inhabitant on whom airmen are to be quartered.

4. The airmen of the billeting party proceed to the quarters allotted to them, inspect them and mark with chalk on the door the name of officers, and the number of airmen the building is to hold. The officer selects headquarters, guard-room, alarm post, sick inspection room, transport park, ascertains the best roads in and out of the area, and informs the billeting party regarding them when reassembled. A rough sketch of roads, etc., in the Area should be made if possible.

5. In telling off personnel to Billets, the following points should be observed —

(*a*) Regard should be paid both to the comfort of the men and the interest of the inhabitants.

(*b*) Staff Officers should be on main communications and easily found.

(*c*) Transport drivers must be near their transport.

(*d*) Both sides of a street should be allotted to the same Unit, to prevent confusion in case of alarm.

(*e*) Roads and communications must never be blocked,

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6. Close billets are adopted when a greater state of readiness is required than is possible in ordinary billets. Tactical considerations have precedence over considerations of comfort. As many men as possible are billeted, and the remainder bivouac.

Billets may be of three descriptions, viz. :—

(*a*) Billets with full subsistence.
(*b*) Billets with partial subsistence.
(*c*) Billets without subsistence.

When billets with subsistence are provided, officers and others must be satisfied with the usual fare of the householder on whom they are billeted. Neither bedding nor furniture in billets can be demanded as a right. All billets will include attendance, and—when required—the use of ordinary cooking utensils belonging to the inhabitants.

1. Billeting Demand on Civil Authorities.

As an Officer of the British Air Force, I, acting under powers conferred upon me, hereby direct the Local Authorities of..... to supply billets for :—

Officers.						
Air Marshals. Air Commodores. Group Captains.	Wing Commanders. Squadron Leaders.	Flight Lieutenants. Flying and Pilot Officers.	Warrant Officers.	Flight Sergeants and Sergeants.	Airmen.	Subsistence required. (Insert number of meals per day, number of days, etc. If no subsistence is required, insert the word "none.")

In the event of subsistence being demanded and provided, the question of payment therefor will be taken up on production of the requisition receipt notes, which must be transmitted to the officer in command of the nearest British garrison.

In case of any disobedience on the part of the inhabitants in complying with the demands, the local civil authorities will address the undersigned without loss of time, in order that military force may be applied if necessary.

Place .....
Date .....
Signature of Officer .....

* Alter as necessary if payment is to be made on the spot.

2. Billeting Order on Inhabitants.

(Issued by the mayor, magistrate, chief police officer or other local authority.)

Number of Billeting Demand.....

(1) Quarters for—

Air Marshals,
Air Commodores,
Group Captains,
Wing Commanders,
Squadron Leaders,
Flight Lieutenants,

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Flying and Pilot Officers,
Warrant Officers,
Flight Sergeants and Sergeants,
Airmen.

are to be provided,* together with subsistence as follows:—

by..... (Name).....at No.....
.....Street.
Place and date.....
..... Signature of the Head of the Community.

* Strike out if no subsistence is to be provided.

11. CAMPS AND BIVOUACS.

1. General.

1. In the presence of an enemy tactical considerations (*e.g.*, favourable ground for defence in case of attack, concealment, facilities for protection and economy in outposts), are of first importance.

2. The following rules must be observed in distributing personnel:—

(*a*) Depôts and Parks should be near good roads, with rail facilities if possible.

(*b*) Staffs and Hospitals have first claim on buildings.

(*c*) Hospitals should be given a quiet spot and the most sanitary position.

(*d*) Staff and Telegraph offices should adjoin if possible and should be clearly marked.

(*e*) Officers must be close to their men.

(*f*) Pilots and Observers should be near their aeroplanes.

3. Camp Sites.

3. CAMP SITES are chosen by Staff Officers and Medical Officers and, apart from tactical consideration, regard must be had in selecting sites to the length of time the occupation is likely to last, to elevation, aspect, the neighbourhood of water, accessibility to a road, etc. It is a safe plan to regard prolonged occupation as possible even in what seems likely to be only a temporary camp.

4. Avoid sites that have recently been occupied. The site should be on raised ground or on a gentle slope, dry, and on grass if possible. The base or summits of hills should be avoided. Clay soil should be avoided if possible, and gravel or sand chosen. River beds, ravines and depressions in the ground are bad sites. Tilled, irrigated, damp lands, "made ground," and the ground close to villages and old grave yards should not be chosen as sites.

Although the neighbourhood of trees is desirable, it is best not to form camps under trees or in places where there is thick undergrowth. Rank vegetation shows dampness of site and must therefore be avoided.

5. Good water supply is essential. Other points to be considered are the facilities offered for obtaining shelter, fuel, and in some circumstances, forage and straw.

6. The ground should be prepared before pitching tents or bivouacs, long grass, stones or rubbish being removed. Long grass and bushes within the camp harbour insects, hide refuse, and make it difficult to detect fouling of the ground.

7. The form of the camp must be goverened by the space available. Enough space between tents should be allowed to make it possible to shift every tent one tent's space forward or to the side, and thus allow the ground covered by the tent to be exposed to the sun from time to time.

8. On arriving within two or three miles of the site, staff officers of formations should ride ahead with representatives of units. The latter receive instructions concerning arrangements for the night, lead their units to the ground allotted them, and explain arrangements.

9. Each commander must be informed of any localities or depôts outside his own area for which he may draw for water, fuel, etc.; also which roads he may use and any special defensive or other measures he is to take.

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10. When British and Indian troops camp together avoid putting slaughter places near Hindu troops. The slaughter places should be screened from view. British troops must not be allowed near native cooking places or watering places, nor must they touch their cooking utensils.

11. If it is necessary to select a camp in a mountainous district, the necessity for occupying the chief points from which snipers can fire into the camp and for forming a defensive perimeter round it should be borne in mind.

12. For ground space required for various tents and hangars *see* Section 18.

For space required for transport *see* Section 38.

Bivouac Shelters.

13. Under some circumstances it may be necessary to improvise shelters.

Bivouac Shelters can be arranged in many ways.

In Fig. 9, two forked sticks are driven into the ground with a pole resting on them; branches are then laid resting on the pole, thick end uppermost, at an angle of about 45°, and the screen made good with smaller branches, ferns, etc.

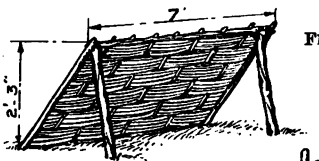

FIG. 9.

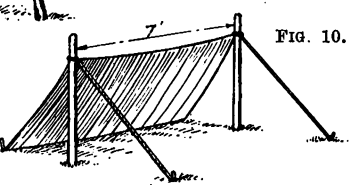

FIG. 10.

SHELTER TENT.

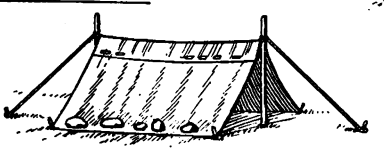

FIG. 11.

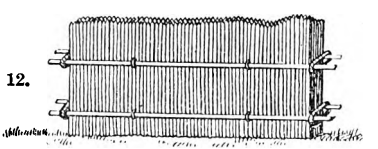

FIG. 12.

A hurdle may be supported and treated in a similar way.

In Fig. 10, a waterproof sheet, blanket, or piece of canvas is secured by poles and string.

In Fig. 11, a tent d'abri for four men is shown, formed with two blankets or waterproof sheets laced together at the ridge, the remaining two blankets being available for cover inside.

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In Fig. 12, a wall of straw or reeds is nipped between two pairs of sticks tied together at intervals.

When the only materials available are earth and brushwood, a comfortable bivouac for 12 men can be formed by excavating a circle with a diameter of 18 feet, or thereabouts, and piling up the earth to form a wall two feet or three feet high. The men lie down like the spokes of a wheel, with their feet towards the centre. Branches of trees, or brushwood stuck into the wall, improve the shelter.

Huts can be made by thatching with stalks of any grain. In the absence of ropes, creepers can be used if available.

12. CAMP COOKING.

1. To cook rapidly and well is an art which can be easily acquired, and which every airman should learn. It is a matter of paramount importance that airmen's food be carefully looked after, and this duty should be *attended to by the officers themselves*, who should also be masters of the art of improvising cooking ovens, etc., out of empty biscuit tins, barrels, or preserved meat tins.

BUTCHERING.

2. On service it may be necessary for Airmen to butcher their own meat ration. The following is a rough and ready guide to such work.

Every edible portion of the animal is available for stewing purposes, but to ensure an even distribution of ration meat, units should always be given an equal share of roasting and stewing joints, as shewn in figures 13 and 14, the letter "R" indicating roasting portions, and the letter "S" the boiling or stewing joints. Butchers and cooks should be conversant with these figures, and cut up and distribute meat accordingly

Mutton.

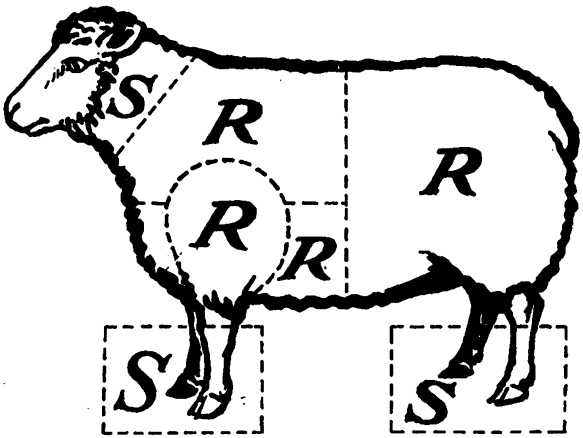

FIG. 13.

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Beef.

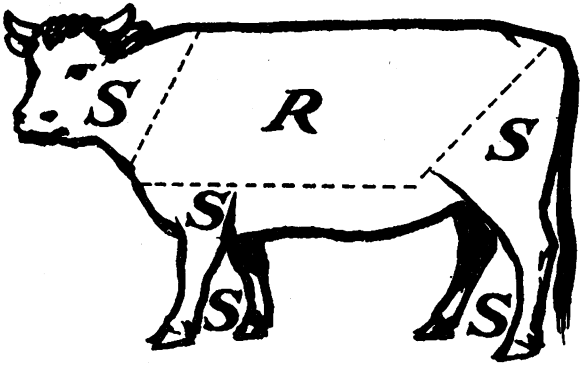

FIG. 14.

MESS-TIN OR CAMP KETTLE COOKING.

3. A meal can be quickly prepared in this manner where time does not allow of an oven being built.

The capacity of a camp kettle is as follows ;—

Name.	Weight.	Contents.	Surface Diameter.	Depth, outside measure.	No. of men will cook for.	
					With vege-tables.	Without vege-tables.
	Lbs.	Gals.	In. In.	In.		
Oval, large -	8	3	$13\frac{1}{2} \times 9$	11	8	15
Oval, small -	4	$1\frac{1}{4}$	$12\frac{1}{2} \times 8\frac{1}{2}$	8	5	8

The mess-tins or camp kettles should be placed on the ground as shown, with the opening facing the direction of the wind (*see* Fig. 15).

Eight is a convenient number of tins to form a "kitchen" but any number from 3 to 10 or 11 can be utilised.

The handles of the vessels should be kept outside.

Mess-tins should be well greased on the outside before being placed on the fire; if this is done and if they are cleaned soon after being used, they will suffer no damage. The tins when they are hot can be cleaned in a few minutes with turf, sand, or rag.

At each field kitchen there should be provided a place for cleaning utensils. This should have a table or boxes to serve as a table, a straining pit, a sufficiency of clean cloths and as much hot water as possible. If sand is used for cleaning vessels, it should be previously baked over a fire and kept in a tin or box near the cleaning bench. Ashes from a wood fire may be used in place of sand. The whole process should be supervised by one of the unit sanitary detachment

Only a small quantity of wood is required for each "kitchen," a good draught being the object to be kept in view. The fuel used should be

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that obtainable in the vicinity of the "kitchens." When mess-tins are used each man should be instructed to prepare his own food; but when once the "kitchen" is formed and the fuel collected, one man only need remain with each fire.

FIG. 15.

The position of the tins in each "kitchen" will require to be changed from time to time; otherwise some will be cooked sooner than others. It will be the duty of the man in charge to regulate this.

The dinners can be cooked in 1½ hours from time of placing the kettles on the fires.

The following dishes are suitable for this method of cooking:—Plain Stew, Irish Stew, Curried Stew, Sea Pies, Meat Puddings and Jam Rolls.

Small joints of meat may be baked in the Service camp kettle. A small amount of fat should be placed in the bottom, then a few clean pebbles large enough to cover the fat; the joint should be placed on the pebbles, and the lid put on. It requires a little longer to cook a joint in this way than in the ordinary oven; it is hardly possible to perceive any difference in the taste.

It is estimated that dinners for 1,000 men can be arranged in a space of 40 yards by 30 yards, allowing an interval of two feet between the "kitchens." When possible, however, more room should be given, as the men attending the fires are then less inconvenienced by the smoke.

COOKING, VARIOUS METHODS OF.

4. The various methods of cooking in the Service are roasting, baking, boiling, steaming, stewing, and frying, and may be described as follows:—

Roasting.

5. Roasting may be performed in two ways: (i) with an open fire place; (ii) in an oven.

(i) To roast meat is to cook it by exposing it to the direct heat of the fire (360° Fahr.). The fire must be bright and fierce.

To preserve its nutritious matter, the meat should at first be placed close to the fire, basted and lightly dredged; by doing so the exterior of the meat becomes hard, thus preventing the escape of the juices. Then withdraw it to a greater distance from the fire and baste until done.

The time required is 15 to 18 minutes per 1 lb. weight; but that must be judged by the thickness of the joint and the quality of the meat. Young and fat meat requires longer than old and lean.

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If, on pressing the lean part with the flat portion of a knife, the meat yields easily, or if the steam from the meat draws towards the fire, it is done.

The loss in roasting is from 30 to 35 per cent., being the greatest average loss in cooking.

Basting is pouring fat or dripping over the meat from a pan placed underneath.

Dredging is shaking over the meat dry flour or bread crumbs and salt mixed.

(ii) The distinction between what is commonly called a roast and a bake is small. With the former the meat is resting on a trivet (as with a Yorkshire Pudding), and to a certain extent the whole surface of the meat is exposed to the dry heat of the oven; with a bake a certain portion of the meat is resting on the potatoes, and becomes partly cooked before being turned. For roasting the oven must be thoroughly hot before the dishes are placed in it; the joint must be frequently turned, and the dishes moved in the oven so that each portion of the meat may be equally cooked. Baste and dredge frequently. The meat may be either larded or barded previous to cooking. The former is the insertion of pieces of fat in the flesh or on the surface of the meat; the latter is covering lean meat with fat to impart a richness it would not otherwise possess; both processes are similar to basting.

Baking.

6. Baking is a most convenient, economical, and satisfactory mode of cooking certain dishes, such as pastry, meat pies, pork, shoulder of mutton, etc.

The best oven for baking is one sufficiently ventilated to allow the steam rising from the meat to escape.

In baking pies, etc., they should at first be placed in the hottest part of the oven. When the paste is cooked, they can be left on the bottom to simmer until done. Pork or other meats of a similar nature should be covered with a greased paper, to prevent the fat melting too quickly.

The average loss in baking is 25 per cent.

The heat required to bake meat is at least 345° Fahr.; but more is necessary should there be much stock or any potatoes in the dish.

Meat previously wrapped up in paper or cloth may be baked as follows:—Dig in the ground a hole of sufficient size and build a fire in it. After the fuel has become red hot, put on the meat with the skin on, over a thick layer of green grass. Cover with green grass, hot ashes and earth. Build a good fire over the meat and keep it burning for six hours. Meat treated in this way at night will be found cooked in the morning.

Boiling.

7. The boiling point of water is 212° Fahr., but if salt be added 220° Fahr. will be reached.

Meat.—To boil a joint of meat for table, it should be placed in boiling water, and allowed to boil quickly for 10 minutes. Then bring it to a simmer, and allow it to remain at a temperature varying from 180° to 190° Fahr.; it should be surrounded with plenty of water and the lid of the vessel kept on, care being taken that the scum rising to the surface of the water is frequently skimmed off; otherwise the appearance of the meat will be spoilt.

By placing the meat in boiling water the albumen becomes solid and prevents the escape of the juices.

If soup only be required, the meat should be cut into small pieces placed in cold water, and allowed to simmer slowly in order to extract its juices, as in preparing beef-tea.

Salt beef or pork should be previously soaked and washed in cold water; then placed in a vessel containing cold water, and allowed to boil slowly for one hour. The water in which it has been boiled should then be thrown away. Refill the boiler with fresh cold water, and simmer gently until done. Salt meat requires a little longer time for cooking than fresh. It is placed in cold water in order to extract the salt or brine; if put into boiling water the meat would become hard and indigestible.

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The average loss in boiling meat is 15 to 20 per cent.; the time required to cook depends upon its weight and compactness; as a general rule 15 to 20 minutes per one pound weight.

8. *Vegetables.*—In boiling vegetables to be served separately, they should be placed in boiling water, with a little salt, and boiled quickly until tender, which will cause them to retain their saccharine juices; but if for soup they should be placed in cold water and boiled slowly in order to extract the juices.

Cabbages, greens, etc., should be thoroughly cleaned and allowed to remain for a short time in salt water; this will destroy any small insects that may remain. They should then be placed in boiling water with a little salt and soda added, and boiled quickly until tender; then taken up, strained, and served very hot. The boiler should be kept uncovered, as this not only helps to preserve the colour, but allows the indigestible part to pass away.

Potatoes take from 20 to 30 minutes boiling. Carrots and parsnips 20 to 45 minutes. Soak dried vegetables about four hours, and then boil slowly.

Indian corn yams, and plantains can be left over the camp fire at night. The first requires a good deal of cooking and a little animal fat or edible oil should be mixed with it.

9. *Puddings.*—Puddings should also be placed in boiling water. The water should be kept at a steady boil. Flour, when used as a thickening in soup, requires 30 to 40 minutes' boiling; oatmeal from 50 minutes to one hour.

Stewing.

10. Stewing is considered the most profitable method of cooking. If properly performed, tough meat is rendered tender and wholesome, and more nourishment is obtained than by any other process. It should be distinctly understood that stewing is not boiling; all that is required is a gradual simmering, that is, from 170° to 180° Fahr. By this process the coarsest and roughest parts of the beast will become soft, tender and easily digestible.

The best method of stewing is by steam.

Meat of a fibrous and coarse nature, such as legs, briskets, buttock, clods or necks of mutton, should be issued for stewing.

Braizing.

11. Braizing is stewing meat by placing it in an air-tight stewpan, and the heat applied above as well as below; or it can be put in a very hot oven, with a small quantity of water in a dish. Average loss in braizing is 10 per cent.

Steaming.

12. Steaming is usually performed by steam passing from a close boiler to a close chamber; or by placing a steamer over a boiler containing boiling water; or by placing a few bricks or stones at the bottom of the boiler, covering them with water, and placing on them the dish containing the articles required to be cooked.

A steamer is a vessel the bottom of which is perforated with a number of small holes. It should never be placed above a boiler until the water is at a sharp boil.

The articles of food usually cooked by steam are meat, potatoes and puddings.

The average loss in steaming is 15 per cent.

About 1¼ pints of water will accumulate from the condensed steam during the process of cooking about 18 rations.

Frying.

13. Frying is cooking with the aid of fats, such as butter, lard, dripping suet, olive or palm oil, which should be sweet, clean, fresh and free from salt. With care the same fat should last a long time; but when it acquires a dark brown colour, it is no longer fit for use.

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DAILY EXPRESS

It is customary to place in the pan only sufficient fat to cover the bottom of it; but, when possible, it will be found better to have sufficient fat to cover the article intended to be cooked. Heat required is from 350° to 400° Fahr.

A way of testing is by spilling a few drops of water into the fat; when the noise resulting from the evaporation of the water ceases, the fat is ready.

The loss in frying depends on the quality of the meat and mode of cooking. If properly performed, there should be none.

Broiling.

14. Broiling is cooking over or in front of a fire, a gridiron being generally used; care should be taken that the latter is perfectly clean and free from grease. It should be placed on the fire slantways, the lower part in front; this prevents the fat falling into the fire and causing it to smoke. The fire must be clear, bright, and tolerably strong.

Meat for broiling should be cut thin and of an even thickness. The meat then will be equally cooked throughout.

Previous to cooking, the meat should be sprinkled with pepper, but not with salt. It should be frequently turned, and when firm to the touch on being pressed with the flat part of a knife, the meat is done.

The average loss in broiling is 8 per cent. With a clean gridiron and clear fire, small dainty pieces of meat and fish may be cooked by broiling in a manner superior to any other process of cooking.

Stock Pot.

15. A stock-pot should be in use in all cook-houses. Usually a large boiler is provided for this purpose, in which bones are allowed to simmer for the purpose of extracting properti s which are invaluable in the preparation of soup, gravies, meat pies, meat puddings, etc.

The bones should be put into old water (add salt) in the proportion of one-third bones to two-thirds water, brought to the boil, and allowed to simmer for about 7 hours. The bones should then be removed and dried, the stock strained and used as required.

Scum should be skimmed from the surface of the stock as it rises. It is a waste product, the presence of which frequently turns the stock sour, especially in hot weather when the fire has been drawn and the stock allowed to cool down.

Each night the boiler should be emptied, the liquor being strained off into clean vessels. The pot should then be washed and aired.

Hay Box Cookery.

16. When fuel is scarce, a good plan is to cook the meat partly in a kettle, and, when the contents are boiling, to place the kettle in a box, surround it with hay or other non-conducting material, and close the lid tightly; a pad made of hay should be placed on top of the cooking vessel before closing the lid of the box. The contents will go on gently stewing and should be fully cooked in three or four hours.

The Hay Box will not cook pastry, which requires the top heat of an oven, or pudding which requires the contents of a cooking vessel to be kept at boiling point. It will not cook cabbage, or certain vegetables which should boil rapidly.

Cooking Apparatus.

Soyer's Stove.

17. This consists of a 12 gallon boiler contained in an iron cylinder, at the bottom of which is a small fire-place.

It will boil vegetables, puddings, etc., for 50 men, and makes a good stock pot in the field.

Ovens and Kitchens.

18. Kettles, portable cookers and ovens form the usual field outfit. In the construction of ovens and kitchens, much depends on what is available locally. A few sheets of corrugated iron are invaluable for constructing ovens. Much scope for ingenuity in officers and men exists with regard to the construction of satisfactory cooking appliances in the field.

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Figures 16, 17 and 18 shew types of cooking trenches.

FIG. 16.

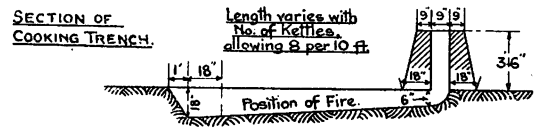


FIG. 17.

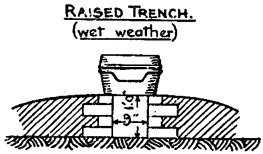
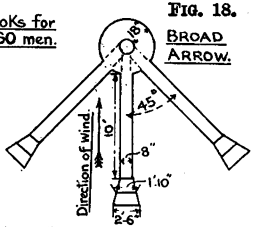


FIG. 18.



Kettles measure:–

12 quarts	9" x 13½" x 11" high.
7 do.	8½ x 12½" x 8" do.

Figure 19 shews an oven burrowed near the top of a bank.
Figure 20 shews an oven constructed of oil drums, a few pieces of sheet iron and bricks or sods, which is capable of cooking for 200 men.

FIG. 19.

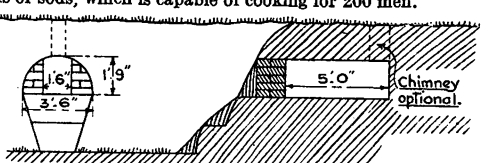
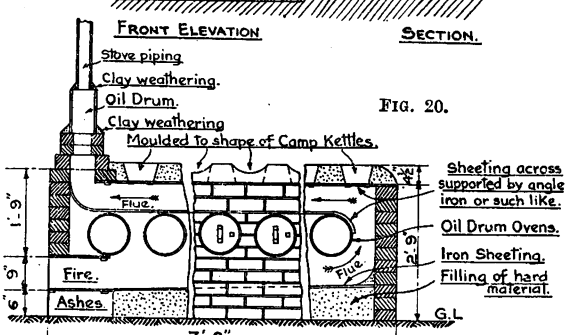


FIG. 20.



SECTIONAL ELEVATION.

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Aldershot Oven.

19. The Aldershot oven consists of :—

2 Sections or arches.
2 ends.
1 bottom.
4 bars.
9 tins.
1 peel.

Total weight :—374 lbs. (about 3¼ cwt.).

The bottom can usually be dispensed with, in which case the above weight is reduced by 66 lbs. The length of the two sections when up is 5 ft. 1 in.; width, 3 ft. 5 ins.

Capacity :—Each Oven will bake 54 2-lb. or 2½-lb. loaves (108 rations) in each batch. or will cook dinners for about 220 men.

20. To erect an Aldershot Oven select a gentle slope, on clay soil if possible; avoid marsh or sandy ground. The mouth of the oven should face the prevailing wind.

The site should be cleared and smoothed, and sods cut to build up the back, front, and sides of the oven. The bars are then placed over the site already prepared, the back one overlapping the front, and back of the oven placed in position. The plate forming the bottom of the oven is then placed against the front portion, and firmly fixed; the sods are built round the front, back and sides. The clay or soil, having been first mixed with water and grass, rushes, etc. to assist in binding it, is then thrown on the oven and well beaten down. The depth of clay or earth should be at least 6 inches. The roof should slope backwards slightly to carry off the rain.

21. The following directions should be observed :—

(i) Every night wood should be laid in the oven ready for lighting in the morning. It is thus kept dry.

(ii) When the oven is heated, the embers are drawn out with a rake, and a small quantity of ashes left and raked even with the floor.

(iii) The tins containing dough should not be put in till 20 minutes or half-an-hour after the fire is drawn, as otherwise the top heat is so fierce that it would burn the upper part of the bread.

When meat is to be cooked it may be put in immediately the fire is drawn.

(iv) Immediately the oven is filled the door should be put up and wedged tightly with a piece of wood, the end of which should rest firmly on the ground.

The crevices round the end should then be filled in with wet clay to prevent any steam escaping. If this is properly done, the steam providing the necessary moisture is retained, and the bread or dinners will not be burnt.

22. *Time for Heating, Baking, Cooking, etc.*

1st heating 1st day	¼ hours.
1st heating 2nd day	2 hours.
2nd and subsequent heating	1½ hours.
Baking	1 to 1½ hours.
Cooking	Up to 2½ hours.

Fuel required for each Oven.

1st heating 1st day	300 lbs. wood.
1st heating 2nd day	150 lbs. wood.
2nd and subsequent heating	75 lbs. (baking).
2nd and subsequent heating	Up to 150 lbs. (cooking).

A rough heating rule for baking bread is to allow 1 lb. of wood for each pound of bread required.

Ash Oven.

23. In camp or trenches, where improvised methods of cooking prevail, wood ashes should not be thrown away. If put in a convenient place, and kept dry and free from other refuse, such vegetables as potatoes,

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onions, etc., may be baked by simply placing them in a single layer in the ashes and lighting the fires used for stewing, etc., over them. Potatoes and onions cooked in this way retain all their natural flavour, and will keep hot a very long time in the ashes.

Other Types of Ovens and Kitchens.

24. Beer barrels make excellent ovens; one end is knocked out, the ground slightly sloped so that it may rest firmly, the sides back and top being covered with clay, well wedged downwards, to become quite hard; the fire is then lit and allowed to burn until the whole of the barrel is consumed; the hoops will support the clay, and the oven may be safely used. Where the clay is good, a small oven may be safely used. Where the clay is good, a small oven may be built of clay alone. Build two walls the required distance apart, about 6 inches high, with clay which has been well beaten and mixed, the back being joined to the walls; then with one hand on each side gradually build the walls a few inches higher, the tops slightly sloping towards each other, leaving an interval in the form of a V in the centre; then mould a piece of clay large enough to fill the space and place it in, care being taken to join the edges with the walls, both inside and out; a small fire should then be lighted and allowed to burn slowly until the clay is dry.

Tin biscuit boxes are a good substitute for an Aldershot Oven. Melt one side of the solder, and form the box into a semi-circular shape; lay it on the ground and cover it with a few inches of clay or soil sufficient to retain the heat; light the fire, and proceed as with Aldershot pattern.

Ant heaps can also be used as ovens, the insides being scooped out and the fire lighted, as in the Aldershot Oven.

Another method is to dig into the side of a bank or trench, and improvise a door with old sheets of tin or iron, plugging up the crevices when cooking, as with an Aldershot Oven.

Recipes.

25. (Those marked * are suitable for Mess-tin cooking.)

Kabobs.—For a hurried meal the meat can be quickly prepared by cutting it into pieces about the size of a penny, but three or four times as thick. These can then be skewered on a piece of wire or hard wood and placed before the fire for few minutes.

**Stewed Beef, Mutton or Fowl.*—Cut up the meat into thin slices or small pieces, the smaller the better. Put a little fat into the bottom of the cooking pot, and when hot put in the meat; stir till brown; add a sliced onion, carrot, or turnip; season with pepper and salt; add a little flour and some hot water; stir well; and allow to simmer slowly till done. Tomatoes, rice and powdered biscuit in lieu of flour may be added.

**Irish Stew.*—Ingredients: Meat, potatoes, onions, pepper, salt. Peel, wash and slice the potatoes; peel, clean and cut up the onions; cut up the meat into small pieces; place a little water in the kettle and a layer of potatoes at the bottom, then a layer of meat and onions; season with pepper and salt; then add another layer of potatoes, and so on to the top, potatoes forming the top layer. Barely cover the whole with water and stew gently for about two hours.

**Sea Pie.*—Ingredients as for Irish Stew, with 5 lbs. of flour and 1½ lbs. suet or dripping added for every 20 men. Prepare ingredients as in case of stew, cutting the potatoes in slices lengthwise, and cover with paste making a hole in the centre. To make the paste, mix flour and water roll or beat it out with the hands on a flat surface, adding a small teaspoonful of baking powder for each pound of flour. The paste should be about ½-inch thick. Time required to cook, about two hours.

**Mutton or Beef Soup.*—For 6 persons: 1½ lbs. of meat, 1 onion, 2 carrots, 1 turnip, 6 tablespoonfuls of rice or barley. Cut the meat up into small pieces; peel and slice the onion; clean and cut up the other vegetables; put a little fat into the camp kettle; fry the meat and vegetables a light brown colour; add 5 pints of water and the rice or barley; stew slowly for about 1½ hours, taking off the scum as it rises; season with

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pepper and salt, and serve. When time does not admit, the frying of the meat and vegetables may be dispensed with. Semolina, tapioca, sago, macaroni, tomatoes, green peas, beans, lentils, etc., can be substituted for the rice or barley.

**Beef Tea.*—Cut up about 1 lb. of lean beef (no fat) into small pieces; put in a kettle; add 2 pints of cold water; boil slowly, removing the scum as it rises; cook for about 2 hours, or longer if time permits. Strain and serve.

**Troopers' Steak.*—Put quantity required of thick steak into a mess-tin or camp kettle, leaving only a little of the fat; pour on enough water to come half-way over the steaks. They should fit closely together in the vessel. Sprinkle with finely minced shallot, onion or chopped celery, flavour with pepper and salt. Cover the pan closely for an hour; let simmer gently, but never boil; dredge any vegetables to hand with flour after the meat is removed from the mess-tin or kettle; boil them up in the liquor, and serve on top of the steaks with the gravy.

Salt Meat, when required hurriedly, should be cut into thin slices, placed in cold water, and brought to boiling point to extract the salt; this may be repeated until the meat is found palatable. Salt meat treated in this way may, if time will allow, can be used for stews in the same way as fresh meat.

** Stew made of Preserved Meat and Vegetables.*—Cut up the meat, removing all fat and jelly, powder up the vegetables, and put them in a kettle or mess tin with water; cook until done; strain off most of the water; add meat and jelly, and season with pepper, salt, and a teaspoonful of brown sugar. Put on the lid, and allow to heat through; then serve. The secret of making palatable dishes with preserved meat is only to heat it through, as cooking spoils it. If fresh vegetables are obtainable, they should be fried first, then stewed, and added to the meat.

** Brown Stew with Preserved Meat.*— Peel and slice some onions; melt the fat of the meat in the camp kettle or mess-tin; add the onions and fry them till brown; mix a little flour into a smooth batter with cold water, season with pepper and salt, and pour it into the camp kettle; stir the whole well together; cut up the meat into slices, put it into the kettle, and, when warmed through, serve.

** Preserved Meat Soup.*—Take four ozs. of meat and half a biscuit per man with his allowance of preserved vegetables; cut up the meat, and powder the biscuit and vegetables. Put the vegetables into a camp kettle containing ½ pint of cold water per man; boil slowly; add the meat and biscuit, and continue the boiling for half-an-hour; season with pepper and salt if required, and serve; a quarter of a teaspoonful of brown sugar for each man may be added to improve the flavour.

** Preserved Meat Fritters.*—Ingredients: Half a pound of beef or mutton, ½ lb. of flour, ½ pint of water, 2 ozs. of butter, the whites of two eggs. Make a smooth batter with the flour and water; stir in 2 ozs. of butter, which must be melted but not oiled, and, just before it is to be used, add the whites of two well-whisked eggs. Should the batter be too thick, more water must be added. Pare down the beef into thin shreds, season with pepper and salt, and mix it with the batter. Drop a small quantity at a time into a pan of boiling fat, and fry from 7 to 10 minutes, according to the size. When done on one side, turn and brown them on the other; let them dry for a minute or two, and serve. A small quantity of finely minced onions mixed with the batter is an improvement.

** Tomato Cheese.*—Ingredients: Fresh tomatoes, strong cheese (any kind will do), salt, pepper, and breadcrumbs. Slice the tomatoes and finely grate the breadcrumbs and cheese. Put a layer of tomatoes into a camp kettle, mess-tin, or empty beef tin (previously greased and sprinkled with breadcrumbs), then pepper and salt, and a layer of breadcrumbs and cheese, and so on, till the vessel is full. The top layer should be of bread crumbs. Dot with pieces of butter, fat, or dripping, and bake in a quick oven for half-an-hour.

** Fried Eggs and Rice.*—Parboil some rice in salted water. Then simmer till quite cooked in some good gravy, and add half a teaspoonful of curry

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powder when done. Keep hot in a camp kettle or mess-tin. In the meantime, fry as many eggs as required in hot fat, taking care not to break the yolks; lift them out and place on the rice, scatter some finely-chopped parsley over all, if procurable, and serve hot.

Plain Rice Pudding.—Boil 1 lb. of rice in 6 quarts of water for 30 minutes, season with a pinch of salt, strain and save the water; put the rice into a dish; add 6 ozs. of sugar, half a tin of condensed milk and a little of the water which has been strained off; stir well; grate a little nutmeg or rind of a lemon on the top, place the dish on some embers, cover with a piece of tin; on this put some more embers, and bake for 20 minutes. If fresh milk is used, add two more ozs. of sugar. If milk is not obtainable, the rice water alone may be used. If an egg is added, it should be beaten up with the milk or rice water; this is a great improvement.

Chupatties.—Mix some flour with water to make a stiff dough. Flatten a piece of the dough with both hands until it is about ¼ inch thick. Melt some fat in the cover of a mess-tin, and when quite hot place the chupattie in it and leave till it is brown on both sides. On an average fire 1 lb. of flour can be made into chupatties in half-an-hour.

Bread made with Baking Powder.—Spread the flour out evenly, sift the baking powder over it, taking care to break up any small lumps. Mix powder and flour thoroughly. Dissolve salt at the rate of 1 oz. to 7 lbs. flour in the softest water available. Mix with the flour and powder very thoroughly, and place the loaves in a quick oven.

To make Stale Bread new.—Cut the bread into fairly thick slices. Have ready a mess-tin of boiling water. Remove the lid and place a slice of bread over the steam for a few seconds; then turn it to the other side for the same amount of time. Remove quickly and butter. Bread treated in this way is as tasty as hot rolls, and it makes no difference how stale the bread is.

* *Barley Water.*—Put into a kettle 7 pints of water and 2 ozs. of barley; stir now and then when boiling; add 2 ozs. white sugar and the rind of a lemon thinly peeled. Let it boil gently for about an hour without covering it, then pass it through a sieve or colander; it is then ready.

Lemonade.—Put into a basin two tablespoonfuls of brown sugar and 1½ tablespoonfuls of limejuice; mix well together for half a minute, add 1 pint of water, and the beverage is ready.

Milk.—Milk (other than sterilised or condensed) should be boiled before use.

13. SANITATION AND WATER SUPPLY.

Sanitation of Camps and Bivouacs.

Prevention of Disease.

1. The importance of the prevention of disease on field service cannot be overestimated. Neglect of sanitary measures invariably results in great loss of life; disease may assume such proportions as to paralyse the efficiency of a force. It is the duty of both officers and men to comply strictly with orders relating to the preservation of health. To keep himself healthy and fit is a duty that every airman owes to his country, his comrades, and himself.

2. Whether the camp is to be occupied for a short or long period, it is essential that the ground it covers should be kept clean and this is materially aided by keeping the surface dry; in camp, channels should be cut to drain the ground and to carry off the rainwater from the trenches surrounding the tents.

3. Nothing should be allowed to foul the surface; it often happens that refuse from tents, such as meat-tins, bones, washings from men's mess tins, etc., are thrown on the ground outside the tents and that at night men will urinate there, especially if the urine pits or receptacles are far away, and there is want of supervision. All these cause fouling of the surface of the ground and may become a grave source of disease.

In camp equipment there are no receptacles provided for tent refuse. They should be improvised from biscuit tins, boxes, etc., and placed near the tents or bivouacs and emptied daily into the camp incinerator.

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Urinals and Latrines.

4. Urinals and latrines should be made immediately on arrival at a camp or bivouac, and should be filled in at the last possible moment. Provision should also be made for night urinals close to the lines, and men should be punished for urinating outside their tents or otherwise fouling the ground.

5. Latrines, urinals, refuse pits, horse and cattle lines, and slaughtering places must be placed as far as possible from the kitchens and from any source of water supply, and to leeward if possible. They must never be placed in any gullies which, when it rains, may discharge into the water supply. A sanitary policeman should be placed in charge of each latrine, his duty being to see that every man covers up his excreta with earth. Failure to carry out this practice should be punished.

Slaughtering places should not be near horse lines.

6. In camps, short trench latrines should be dug. Each trench should be 3 feet long, 1 foot wide, and 1 foot deep, the interspace between each trench being 2½ feet; men should use these trenches straddlewise, and at once cover up their deposit with earth. Five trenches will suffice for 100 men for one day; they should then be filled in with earth and the turf replaced.

Trenches required for the second day of occupation will be dug in the spaces between the first row of trenches.

The method of preparing the short trench latrine is shown in Fig. 21.

FIG. 21.

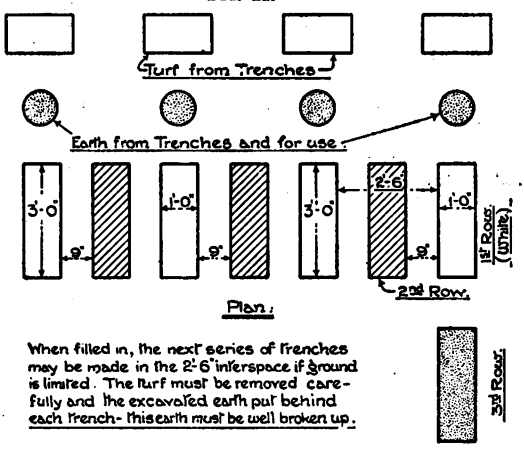

Turf from Trenches
Earth from Trenches and for use.
3'-0"
9"
1'-0"
9"
3'-0"
2'-6"
1'-0"
9"
1st Row. (White).
2nd Row.
Plan.
When filled in, the next series of trenches may be made in the 2'-6" interspace if ground is limited. The turf must be removed carefully and the excavated earth put behind each trench- this earth must be well broken up.
3rd Row.

FIG. 22.

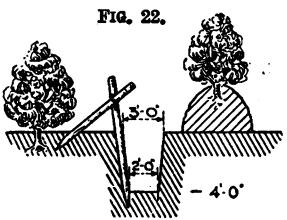
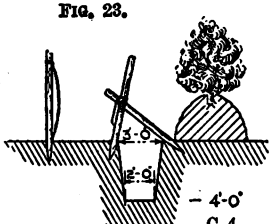


FIG. 23.



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If the area of ground be limited, the depth of the short trench may be increased to 2 feet; these deeper trenches should last 2 days.

In some cases, deep latrines may be necessary; they should be constructed to seat 5 per cent. of the troops, 1 yard per man being allowed. This type of latrine is shown in (Figures 22 and 23).

The position of all old latrines should be marked with the letter "L" made with stones.

Arrangements must be made to prevent the excreta in trenches ever remaining uncovered with earth. Latrine paper should be supplied.

7. Urine pits in addition to latrine trenches must also be provided and their conservancy supervised with the same amount of care. Cubical pits should be dug and filled with perforated tins, brick bats or clinker. Urinal funnels improvised from biscuit tins, cresol drums, etc., drain into these pits through pipes inserted deeply into the filling material.

Camp Kitchens.

8. Great attention must be paid to camp kitchens. Kitchen slop water should be disposed of in pits covered with brush-wood, straw or any other material that will retain the grease. The brushwood, etc., should then be used as fuel in the kitchen fires. The habit of throwing kitchen water about to allay dust increases instead of diminishing discomfort in camp. An ablution place must be formed and all washing done there, the sloppy water being conveyed into soak pits or otherwise removed to prevent fouling of the surface in the vicinity.

9. Food must be protected from dust and flies. To keep camps free from flies, horse dung, stable litter and other refuse, which form natural breeding places for those insects, must be carefully disposed of.

Refuse of all descriptions should be burnt daily, and what cannot be burnt should be buried. The carcases of dead animals should be removed from any ground likely to be wanted for camping, disembowelled, and the viscera buried deeply. In standing camps the carcases should be burnt or buried.

Incinerators.

10. Drawings of incinerators for disposal of camp refuse are shown in Figs. 24 and 25.

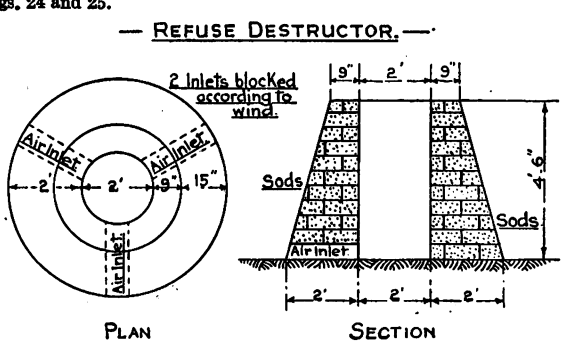

FIG. 24.

The site should be carefully chosen in order to prevent nuisance and avoid any possibility of fouling the water supply.

11. To keep tents dry they should be trenched; flies of tents should be rolled up daily, and blankets and kits aired.

12. Cleanliness both of person and clothing is of great importance. The feet should be washed or wiped at least once daily. The nails, mouth

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and hair require attention as well as the skin. Underclothing should be washed at least once a week.

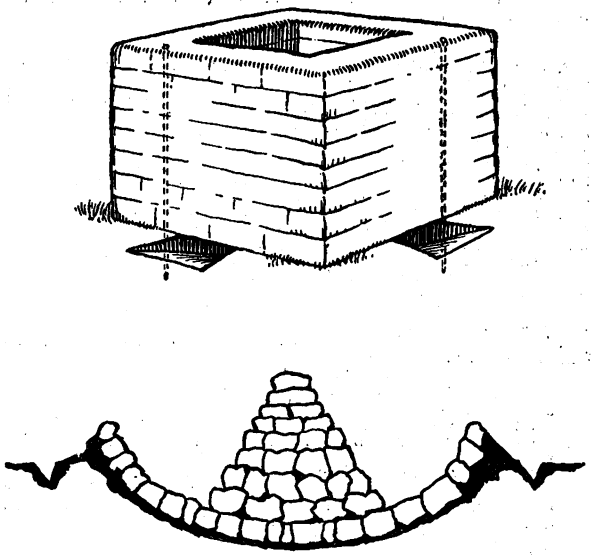

FIG. 25.

Disinfectants.

13. For general use, cresol solution and chloride of lime are the most efficacious. To use cresol, mix 1½ ozs. of cresol solution with 1 gallon of water.

WATER SUPPLY.

Quantities required.

1. A daily average of 1 gallon per man is sufficient for drinking and cooking purposes. A horse, bullock, or mule drinks about 1½ gallons at a time. In standing camps, an average allowance of 5 gallons should be given for a man, and 10 gallons for a horse or a camel. An elephant drinks 25 gallons, each mule or ox 6 to 8 gallons, each sheep or pig 6 to 8 pints. These are minimum quantities.

One cubic foot of water = 6¼ gallons (a gallon = 10 lbs.).

Yield of Streams.

2. The rough average yield of a stream may be measured as follows:—Select some 12 or 15 yards of the stream where the channel is fairly uniform and there are no eddies. Take the breadth and average depth in feet in three or four places. Drop in a chip of wood and find the time it takes to travel, say, 30 feet. Thus obtain the surface velocity in feet per second. Four-fifths of this will give the mean velocity, and this multiplied by the sectional area will give the yield per second in cubic feet of water.

A small stream may be measured as follows:—Cut a triangular notch in a plank, with sides at 90°. Dam up the stream so that it flows away

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through the notch. Measure the height from the bottom of the notch to the surface of the water where it is not affected by the overfall. The discharge in gallons per minute = $1 \cdot 978\ h^3\ \sqrt{h}$ where h = height above bottom of notch in inches.

Purity.

3. As the health of a force depends largely on the purity of the water provided, everything possible must be done to ensure an ample supply of pure drinking water, and to keep it pure when obtained. It is mainly through drinking impure or contaminated water that cholera, dysentery, and enteric fever are contracted and spread. The water supply will always be selected in conjunction with the sanitary or other medical officer, who will satisfy himself as to its fitness for use. No water should be used for drinking purposes that has not been sterilised by filtration, by heating, or by chemical means.

4. Men must be prevented from drinking water from unauthorised sources, and they must be trained to economise the contents of their water bottles, which, before marching, should be filled with weak tea or sterilised water. Bad water drunk on an empty stomach is more dangerous than that drunk with a meal. Thirst is best assuaged by first moistening the lips and mouth, and only drinking a small quantity at a time. Large draughts of water should never be taken, as thirst is only increased thereby, and, if taken when the body is overheated, bad effects may follow.

5. The sources of water may be considered to be, as a rule, in the following order of purity :—

(*a*) Artesian wells and deep borings—water from these is above suspicion as it issues from a geological stratum that is covered by another stratum impervious to surface or ground water.

(*b*) Deep wells when properly constructed and protected.

(*c*) Springs are safe if no dwellings with drains and cesspools are near.

(*d*) Rainwater, if freshly caught in clean vessels.

(*e*) Small streams are safest near their sources; dwellings and grazing grounds on or near their banks and draining into them are dangerous sources of contamination.

(*f*) Large lakes supply good water if it be taken at a distance from dwellings, and if the lake be not weedy or muddy but clear with a rocky firm bottom.

(*g*) River water varies. Towns and villages on their banks contaminate river water. In sparsely populated districts and when the stream is swift, as in mountain districts, and where there is a great body of water it may be safe to drink the water without purification.

(*h*) Shallow wells are unsafe, although they often appear clear and pure, unless well protected by steining, and copings and covers.

(*i*) Ponds and surface collections of water are always unsafe and must invariably be purified before being used for drinking or cooking.

6. Water is generally carried from its source to the camp in water carts, or in iron tanks on wheels; but other vessels such as petrol tins, canvas tanks, earthen chatties, and skins of animals are used.

In all cases the greatest care must be taken to keep these receptacles clean, and they should frequently be inspected and sterilised.

Men must not be allowed to drink direct from the tap of the carts or from the rims or spouts of other receptacles for carrying or distributing water; and all open vessels must have covers.

Protection against dust and other contamination is necessary and the storage tanks must be thoroughly cleaned at frequent intervals.

Purification.

7. Purification of water can be effected by Heat, Filtration and Chemical means. Heat and chemical means kill germs, while filtration excludes them mechanically.

(*a*) Boiling is probably the most certain way of rendering water safe, and with proper organisation and fuel it may be possible in camp to produce by this means a supply sufficient for drinking pur-

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poses. Water may be boiled in camp kettles in quantity sufficient to fill men's water bottles. The kettles must be kept covered while the water cools or until its distribution in the bottles, which must be filled direct from the kettle, can be effected.

Men should be encouraged to boil water in their mess tins in order to train them in this method of purifying their drinking water when on detached duty.

If water bottles are dirty, the labour of purifying water may become useless. It is therefore important that the bottles should be cleansed and sterilised.

(*b*) Filtration of water can be carried out by using porous earth and porcelain filters which are hollow tubes fitted with flanges to metal cases. Examples of these are the Berkefield, Pasteur-Chamberland and Doulton filters. Considerable care is necessary in handling them owing to their brittleness and they require to be frequently cleaned.

Muddy water must be clarified before it is passed through these filters, as otherwise the candles get clogged with an impervious coating of clay. They should be brushed and boiled every three days. The object of this is to destroy germs which, though they cannot pass through the pores of the candles into the water under pressure, will penetrate through them gradually unless treated. Altogether these filters are not suitable for use in the field.

(*c*) Chemical means of purification has proved of the greatest value for field service.

Chlorine derived from bleaching powder, or chlorine gas obtained from liquid chlorine carried in metal cylinders has been mainly used. Bleaching powder is employed with the latest pattern water cart. Chlorine gas is generally confined to purification plants placed on barges and on motors.

8. The following methods may be used to clean muddy water of suspended matter before boiling or filtering.

(*a*) Alum (6 grains to the gallon) stirred into the water and allowed to stand hastens the deposit of suspended matter.

(*b*) Tack a sheet on to a wooden frame so as to form a bag or basin; put a couple of handfuls of wood ashes in the bottom and pour on the water, placing a receptacle beneath to catch the water which percolates through.

(*c*) Rough filtration may be carried out by taking two casks and placing one inside the other, the outer cask pierced with holes at the bottom and the inner near the top; the space between is filled with sand, or gravel or wood charcoal. When these are placed in a stream the water rises through the filtering material between the barrels and flows into the inner one.

To make Charcoal.—Dig a hole 5 ft. diameter and 3 ft. deep; fill with wood and set the whole alight; then cover the top with earth so as to exclude the embers from contact with the air. Leave it untouched for 24 hours before opening.

9. *Water Carts.*—The latest pattern of water cart is so constructed that the water can be clarified by passing through canvas filters before undergoing chemical treatment with bleaching powder in the tank.

The tank holds about 110 gallons of water, and is divided up by cross baffles to break up the water pressure when the cart is on the move. Two metal cylinders are fixed at the front of the cart which carry wire cages, round which the canvas is tightly wound. The cylinder head contains a fine wire gauze receptacle through which the water must pass; in this are placed four scoopfuls of a mixture of aluminium sulphate and sodium carbonate. The water passing through the cylinder head takes up the chemical and deposits a gelatinous layer on the surface of the canvas filter. Until this layer is formed, filtration is imperfect and the water must be allowed to run to waste. It is most important to see that the canvas is tightly and accurately wrapped round the cage. The water must be pumped through the cylinder at about 15 strokes per minute. With both pumps working, it takes about half-an-hour to fill the water

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cart. When there is much suspended matter the canvas requires frequent cleansing, which may be done by scrubbing the cloth and boiling it in the receptacle provided.

With clear water it is unnecessary to use the clarifier.

After clarification the water is tested, using the Horrocks' test outfit in order to ascertain the quantity of bleaching powder required to ensure the destruction of all dangerous organisms. The requisite quantity of bleaching powder is then mixed with water in a cup or other receptacle and added to the water in the tank, being thoroughly stirred with a clean tick.

Whenever possible the treated water should be allowed to stand overnight, but if necessary it may be used after an interval of half-an-hour. Water which has been treated in this way may taste slightly of the chemical used; this may be disregarded as the treatment is quite free from danger.

The tank should be kept absolutely clean. A long handled brush is provided for cleaning purposes, and the tank should at regular intervals be scrubbed out with a solution of bleaching powder slightly stronger than that required to ensure sterilisation.

Bleaching powder must be stored in jars or airtight metal receptacles smeared with vaseline.

One water cart will fill the water bottles of about 450 men.

10. *Bleaching powder* depends for its action upon chlorine or rather the oxygen liberated by this gas. One part per million of available chlorine is required to kill dangerous organisms, and a scoop has been devised which holds about 30 grains of bleaching powder, and provides one part per million of chlorine in the 110 gallon water cart. The Horrocks' test must be carried out in order to ascertain the state of contamination of the water, as an impure water requires more bleaching powder than is necessary in the case of an apparently pure supply. It is obvious that the use of bleaching powder is not confined to the water cart; any suitable receptacle may be used for the process.

11. *Sterilising tablets* are issued for use in the field by mobile units and others who are out of touch with any recognised source of supply. Two of these tablets must be placed in a quart water-bottle and allowed to act for half-an-hour. The chemical used is acid sodium sulphate, and in view of its acid properties water so treated should not be allowed to remain in water bottles longer than is absolutely necessary. These tablets should not be used in water bottles made of German silver, Britannia or white metal, but may be used in aluminium or enamelled iron bottles.

12. *Storage Vessels.*—Vessels or tanks in which drinking water is stored, as well as being carefully covered, should be raised off the grounds and provided with taps. Water carts and barrels require frequent cleaning and periodical disinfection.

To clean water receptacles, dissolve 1 teaspoonful of permanganate of potash crystals in 3 gallons of water and rinse with this solution until a permanent pink colour remains.

Watering Arrangements.

13. Posts on lines of communication should arrange to have enough sterilised water on hand to supply the wants of detachments passing through.

14. As a rule Air Force Police, otherwise the first troops to arrive at a halting ground, will mount sentries on all water likely to be required for use with such orders as will prevent any form of pollution. These sentries will not be withdrawn until permanent water guards are detailed.

15. The water supply should usually be marked with flags by the advance party :—

White for drinking water.
Blue for watering places for animals.
Red for washing or bathing places.

16. If water is obtained from a stream, any horses will be watered below the place where troops obtain their drinking water, but above bathing and washing places. Patrolling will often be necessary for some distance above the spot where the drinking water is drawn.

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17. If running water is not available the supply must be very strictly protected, a rough barbed wire fence being run round it, if possible, to keep animals out. Any animals should in this case be watered by bucket or nosebag; and washing should be allowed only at some distance from the water supply, empty biscuit tins or other receptacles being used to draw water for this purpose.

Similar precautions are often necessary with running water if other bodies of troops are halted lower down the stream.

18. Lift and Force Pumps carried by Army Royal Engineers are capable of supplying 600 gallons per hour at a combined lift and force of 60 feet with 4 men at work, but twice that amount with 2 or 3 men if the height to which the water is to be raised is small.

19. Water for radiators of Aero Engines and M.T. Vehicles will be drawn in clean receptacles below the place where troops obtain their drinking water.

20. Never allow washing where water may filter through to drinking water. Never allow drinking from water from impure or doubtful sources.

14. MEDICAL SERVICES.

The P.M.O.

1. The Principal Medical Officer is responsible for the medical and sanitary services of a Royal Air Force command on active service. He has the right of direct access to the Air Officer Commanding.

2. When military forces are engaged in the same operations, he maintains a close liaison with the Director of Medical Services of the Army Command. With each Group is a Senior Medical Officer.

Sanitary Organisations in the Field.

3. As in peace, so in war, the Commanding Officer of a unit is responsible for all measures connected with the preservation of the health of his unit; the Medical Officer of the unit is his technical adviser.

4. Each unit provides a unit sanitary detachment varying in strength according to the size of the unit. The Medical Officer is responsible to the commanding officer for the supervision of the work of the detachment whose duties comprise the care of urinals, latrines, cookhouses, ablution places and the general sanitation of the camp. Its personnel act as sanitary police in the area occupied by the unit.

5. For units acting in an area independent of the Army, Sanitary Orderlies from the R.A.F.M.S. may be provided for special duties in connection with disinfection, bathing arrangements, and purification and protection of water supplies, working under the orders of the Senior Medical Officer of the Area.

Units working in conjunction with the Army may be provided with trained sanitary personnel of the R.A.M.C., who are mobilised for duties in the area and are placed under the sanitary officer of the district.

These trained sanitary orderlies are available to give technical advice to units, but do not in any way interfere with the sanitary duties and arrangements of the units themselves.

6. Thus each unit is self-contained as regards its sanitary personnel, which accompanies it wherever it goes and operates whether the unit is serving as a whole or is split up into detachments. Each unit is therefore able to carry out essential sanitary arrangements for itself, though when circumstances permit these are supplemented by more elaborate sanitary organisation in which orderlies of the R.A.F.M.S. or R.A.M.C. play their part.

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Sick and Wounded.

7. **General Organisation.**—(*a*) The R.A.F. Medical organisation consists of:—

(i) Collecting units, viz., sick quarters in the field.
(ii) Evacuating units, viz., group or area hospitals fed by aerial or motor ambulances from the collecting units.
(iii) Distributing units, viz.: (*a*) base hospitals, and (*b*) convalescent depôts established at the base where necessary; fed by aerial or motor ambulances or by ambulance trains.

(*b*) Where combined operations are undertaken this organisation will be replaced or supplemented, where practicable, by military units as follows:—

(i) Field ambulances.
(ii) Casualty clearing stations and ambulance trains.
(iii) Military hospitals and hospital ships.

8. **Unit Medical Establishments.**—Every squadron and large unit has a medical officer and a staff of airmen of the medical service, and is provided with medical equipment carried on a motor lorry.

9. When attack from the air or otherwise is expected, unit stretcher bearers, who have been previously detailed by the C.O. from Group V airmen, will report to the medical officer under whose orders they will be for the time being. They will wear an armlet letter "S.B." on the left arm.

10. The duties of the unit medical personnel (assisted by the unit stretcher bearers) are:—

(i) To afford first aid to the wounded.
(ii) To carry cases not able to walk to the unit sick quarters or aid post previously selected.
(iii) To assist medical units after an attack, if required and available.

11. **General System of dealing with Casualties.**—A wounded man is generally first attended by the unit medical officer, and (unless able to walk) is carried by the unit stretcher bearers to the unit sick quarters or aid post. Later he is removed by aerial or motor ambulance to the nearest group hospital.

In combined operations, however, the care of the sick and wounded on the L. of C. is carried out by the Army. Thus, he is removed from the unit sick quarters or aid post by the nearest military field ambulance to a dressing station of that ambulance. Thence he is transferred by means of military motor ambulance convoys through a casualty clearing station to a general hospital on the L. of C.

12. **First Field Dressing.**—Every officer and airman on active service carries a dressing, which is placed in the pocket of the right side of the skirt of the jacket. It consists of a packet of cotton cloth containing in a linen cover two dressings, each composed of 2¾ yards of bandages, some gauze and a safety pin. Simple instructions as to the method of using it are printed on the outer and inner cover.

Medical Notes.

13.

Normal pulse	72 per minute.
Normal respiration	15 to 18 per minute.
Normal temperature	98·4° Fahr.

Treatment of Cases of Emergency.

14. **Bleeding.**—Bleeding may be either external or internal, and may be arterial, venous, or capillary.

(*a*) Arterial bleeding. The blood is of a bright red colour, and at first escapes in spurts.

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Treatment. Expose the wound, apply the gauze of the first field dressing, and first try pressure on the bleeding point with the fingers over this protection; if this fails compress the artery against the bone close to the wound but between it and the heart. Pressure should be maintained until some more permanent means can be employed (such as an improvised tourniquet, or medical assistance procured).
Absolute rest is essential. If the bleeding is from a limb, raise it.

(*b*) Venous bleeding. The blood is of a dark colour; it flows or oozes out, but there is no appearance of pulsation.

Treatment. Lay the patient down, remove any constriction which may be round the limb, elevate the limb, and apply a pad and firm bandage.

(*c*) Capillary bleeding. The blood oozes from the entire surface not from any one point.

Treatment. Bathe the part with cold water, or preferably with hot of a temperature of 130° Fahr., or rather hotter than the hand can comfortably bear, and apply a pad and bandage firmly over the wound.

15. The following table shows the situation of the main arteries and their treatment when wounded :—

Position (*see* Fig. 26).	Name of Artery.	Treatment.
Head - - -	Temporal and facial - -	Apply first field dressing over the wound and bandage tightly.
Arm-pit - - -	Axillary - -	(1) Compress subclavian downwards and backwards behind the middle of the collar-bone
Arm on inner side in line with the seam of the coat - -	Brachial - -	Compress the artery by hand (*see* Fig. 27).
Palm of the hand -	Palmar arch -	*Very Difficult to Treat :* Place a roll of bandage or a firm pad in the hand, close the fingers over the pad and bandage firmly, bend up the arm from the elbow and, if necessary, apply pressure to the brachial artery, as in Fig. 27.
Thigh - - -	Femoral - -	Pressure in the groin by fingers or tourniquet (*see* Fig. 28).
Neck - - -	Carotid - -	Pressure with thumb backward at side of windpipe 1½-ins. above junction of collar and breast bone.

16. An improvised tourniquet may be made as follows: take a handkerchief, a smooth, rounded stone, and a stick. Wrap the stone in the centre of the handkerchief; tie a knot over it and place the stone over the artery; pass the ends of the handkerchief round the limb and tie them securely, leaving sufficient space for the stick to be admitted; pass the stick then between the handkerchief and the skin, and carefully twist it until by tightening the handkerchief the stone is pressed upon the artery with sufficient force to arrest the flow of blood. A pad should be placed between the stick and the skin to prevent the latter being bruised, and the end of the stick must be secured with a bandage to prevent the tourniquet untwisting.
Many other substitutes for the above may be adopted.
The tourniquet should be applied no tighter than is absolutely necessary to stop the arterial bleeding, and should only be used as a last resource. A medical officer should be sent for as soon as possible.

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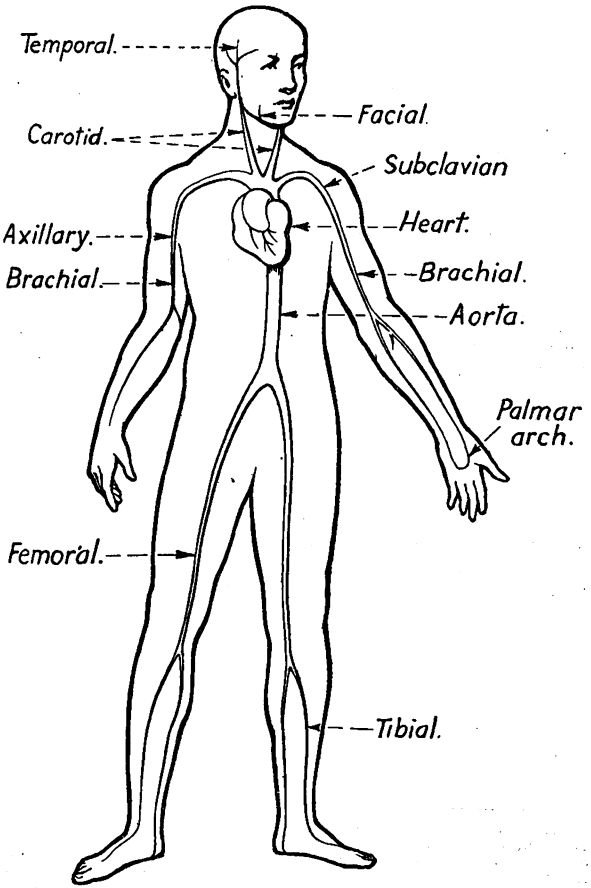

FIG. 26.

17. **Internal Bleeding.**—The symptoms of internal hemorrhage are prostration and weakness. The surface of the body is cold and the face pale, the lips lose their colour. The pulse is weak or imperceptible; there is sighing respiration and a cold clammy sweat.

Treatment.

(*a*) Keep the patient absolutely quiet.
(*b*) Do not give stimulants.

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18. **Drowning; Restoration by Schäfer's Method.**—If breathing has ceased immediately on removal from the water, hold the patient upside

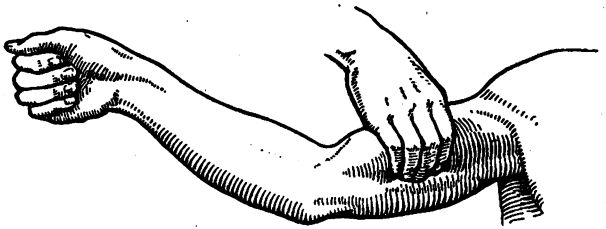

FIG. 27.

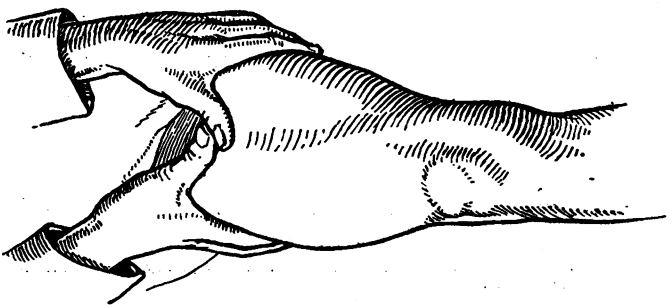

FIG. 28.

down for 3 or 4 seconds to allow the water to run out of mouth and air passages; place the patient face downwards on the ground, with the arms drawn forward and the face turned to the side, or one elbow under forehead.

Then, without stopping to remove or loosen clothing, commence artificial respiration. To effect artificial respiration, put yourself astride, or on one side of the patient's body, in a kneeling or squatting position, facing his head. Placing your hands flat on the small of his back, with the thumbs parallel and nearly touching, and the fingers spread out over the lowest ribs, lean forward with the arms straight and steadily allow the weight of your body to fall on the wrists, and so produce a firm, downward pressure, which must not be violent, on the loins and the lowest part of the back. This part of the operation should occupy the time necessary to count—slowly—one, two, three. By this means the air (and water, if there be any) is driven out of the patient's lungs. Water and slime from the air passages may also run out.

Immediately after making the downward pressure, swing backwards so as to relax the pressure and allow air to enter the lungs. Do not lift the hands from the patient's body. This part of the operation should occupy the time necessary to count—slowly—one, two. Repeat this forward and backward movement (pressure and relaxation of pressure) 12 or 15 times a minute, without any marked pause between the movements.

Whilst the operator is carrying out artificial respiration others may, if there be opportunity, busy themselves with applying hot flannels, hot bottles, etc., between the thighs and to the armpits and feet, or promote

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circulation by friction; but no attempt should be made to remove wet clothing, or give restoratives by the mouth till natural breathing has recommenced.

When this has taken place, allow the patient to lie on the right side and apply friction over the surface of the body by using handkerchiefs, flannels, etc., rubbing legs, arms and body, all towards the heart, and continue after the patient has been wrapped in blankets or dry clothing. As soon as possible after complete recovery of respiration, remove patient to nearest shelter. On restoration, and if power of swallowing has returned, small quantities of warm coffee, tea, milk, wine, etc., may be given. Encourage patient to sleep, but watch carefully for some time and allow free circulation of air around patient.

Note.—Artificial respiration must also be resorted to in case of suffocation by charcoal fumes or coal gas, mining accidents, hanging, lightning stroke, and severe electric shock.

19. **Snake Bites or Poisoned Wound.**—Apply a ligature or tourniquet above the bite, *i.e.*, between it and the heart.

Make ¼ inch deep cruciform incision with a clean knife, and rub in crystals or solution of permanganate of potash.

Give stimulants such as brandy, sal volatile, or hot black coffee.

If breathing is bad artificial respiration should be tried.

20. **Stings of Venomous Insects.**—Apply solution of ammonia, or bicarbonate of soda if available.

21. **Burns and Scalds.**—Apply oil, vaseline, or boracic powder. Cover from air; quickly cut clothes off; never pull them off.

Burns from Petrol.—Cut clothing away from burn and cover with picric acid dressing soaked in water.

22. **Shock, Loss of Consciousness and Fits.**—

Shock.—Put to bed and cover with warm blankets or rugs if possible. Give hot drinks and stimulants if conscious.

Loss of consciousness.—Send for medical aid at once. Lay patient on his back. Loosen all tight clothing round the body. Give no foods or drink unless by medical direction. Allow plenty of fresh air to the patient.

Fainting.—Lay patient on his back, with the head low. Loosen clothing. Allow plenty of fresh air.

Fits.—Lay patient on his back, with the head slightly raised. Loosen the clothes about the neck and chest, and prevent him from biting his tongue by placing the handle of a toothbrush, or similar article, as a gag, between his teeth. Employ sufficient restraint only to prevent him injuring himself. Do not give stimulants.

23. **Sunstroke or Heatstroke.**—Place patient at once in shade or cool place. Allow plenty of fresh air. Raise head and remove clothing from neck and upper part of body. Douche head, neck, and spine, or whole body, with cold water. Do not give stimulants.

24. **Frost Bite.**—Liable to occur when flying in cold weather and at high altitudes.

Signs.—At first bluish tinge of skin, which becomes later waxy white and cold to touch. Patient does not complain of pain until the parts begin to thaw. When this reaction sets in there is great pain and swelling. Blisters form later.

Parts usually affected are ears, nose, chin, fingers and toes.

Treatment.—Do not bring into a warm atmosphere. Rub the affected parts with plenty of cold water, or snow if available, until the circulation returns.

Prevention.—Suitable warm clothing—not too tight. Before flying smear face, fingers, and toes with a thin layer of equal parts of vaseline and lanoline.

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25. **Filings, Dust, etc., in Eyes.**—If loose in eye, remove with corner of handkerchief. If not movable, do not try to take it out. Put a few drops of castor oil into the eye. See a medical officer as soon as possible.

26. **Sprains.**—Bandage firmly as soon as possible after the accident; keep the bandage wetted with some evaporating lotion, or water; raise and rest the injured part.

27. **Wounds.**—Do not attempt to clean up the wound on the field. Stop the bleeding and apply a dressing. In applying the field dressing, care should be taken to place it directly on the wound without in any way touching with fingers either the wound or the surface of the dressing which comes in contact with the wound. This may be done by taking hold of the dressing by pinching it up at the back, turning it inside out, and applying the fresh surface direct to the wound.

28. **Fractures.**—Splints are required for the treatment of broken limbs. They are made of any unyielding substance, such as wood, struts, bark, bundles of twigs, wire, rifles, bayonets, etc., They should be padded with some soft material. They are bound to the limb with bandages, tapes, etc. Cases of suspected fracture should not be moved without first applying a splint.

29. **Flying Accidents.**—In many cases the injured aviator is pinned beneath the wreckage. He should never be dragged out, except in the case of fire, but the wreckage should be cut away from him. This often prevents a simple fracture being converted into a compound fracture.

If the aeroplane is turned upside down in the crash, the pilot may be suspended head downward by his safety belt. Cut the belt and slide the pilot gently out.

In a crash if the pilot is injured but conscious, ask him to move gently each limb in turn. If any of these movements causes pain, it is probable that that particular limb is broken; apply splints (struts can be used as such) and pad with clothing.

Should the pilot have been thrown out he usually injures an arm, his back, or his head.

If pinned in the machine he usually injures his feet and legs and face.

In tractor machines the person in the front seat usually receives the severer injuries. The person in the back seat frequently escapes, or, at most, injures his feet and legs.

As the legs are most often injured, always prevent the pilot, who may be somewhat dazed, from attempting to stand or walk.

The boots should always be removed, and cut away if necessary.

After a crash, even if an aviator seems unhurt, he should never be flown back to the aerodrome in another aeroplane (except aeroplane ambulance). He may faint on the way.

30. **Poisoning :—**

(*a*) **Corrosive.**

Symptoms.—Great pain in mouth and throat immediately after poison has been swallowed. Mouth and throat look as if they had been scalded, lips stained and blistered, shock, difficulty in breathing and breath smells foul.

Treatment.—Do *not* give an emetic. Give scrapings from white-washed ceilings or walls mixed with water.

(*b*) **Irritant.**

Symptoms.—Pain not very marked at first. No staining or blistering of lips. There is a sensation of burning and vomiting, commencing with pain in the stomach, and collapse.

Treatment.—Emetics, *e.g.*, mustard or salt, a tablespoonful to a tumbler of water given until the patient vomits.

(*c*) **Systemic.**

Symptoms.—No signs of burning or redness. There may be giddiness, dimness of vision, drowsiness, difficulty in breathing, delirium, cramps or convulsions.

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Treatment.—Emetics, *e.g.*, mustard or salt. After emetic has worked, give hot coffee; if breathing stops, do artificial respiration.

31. **Dope Poisoning** (due to inhalation):—

Symptoms.—Loss of appetite, feeling of sickness, constipation, pain in back, coated tongue, dryness of mouth, peculiar taste in back of throat, and headache.

Later: weakness, drowsiness, jaundice, itching of skin, giddiness and faintness.

Treatment.—Call in a medical officer as soon as possible.

Prevention.—Small dose of salts each morning. Keep as much in fresh air as possible. A dose of Sodium Bicarbonate and Glucose each day while employed on doping.

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Chapter III.

15. KNOTS, CORDAGE, BLOCKS AND TACKLE.

Knots.

The following knots are commonly used :—

1. To make a stop on a rope, or to prevent the end from unfraying, or to prevent its slipping through a block—the Thumb knot. Fig. 29.

2. To join two ropes together—

Same size (dry)—Reef. Fig. 30.
Different sizes (dry)—Single sheet bend. Fig. 31.
Different sizes (wet ropes)—Double sheet bend. Fig. 32.
Different sizes, or large cables—Hawser bend. Fig. 33.

3. To form a loop or bight on a rope, that will not slip—the bowline. Fig. 34.

4. To form a loop on a drag rope—Man harness hitch. Fig. 35. The loop should be of a size to pass over a man's shoulder.

5. To fix a rope with a weight on it rapidly to a block—Cat's Paw. Fig. 36.

6. To transfer the strain from one rope to another (for use when it is necessary to shift the strain off a rope temporarily.—Stopper hitch. Fig. 37.

7. To secure a spar across a rope—Lever hitch. Fig. 38.

8. To secure a head rope, boat's painter. etc., to a post, ring, or another rope, so that it can be quickly released—Draw hitch. Fig. 39.

9. To secure ends of ropes to spars or to other ropes—
(*a*) Clove hitch. Fig. 40.
(*b*) Timber hitch. Fig. 41.
(*c*) Two half hitches. Fig. 42.
(*d*) Round turn and two half hitches. Fig. 43.
(*e*) Fishermen's bend. Fig. 44.

The Clove hitch may be used for securing centre of rope by passing over top of a post or end of a spar.

10. To secure the end of a rope to the hook of a block—the Single Blackwall hitch or the Double Blackwall hitch, Figs. 46 and 47. The Clove hitch, Bowline, Cat's paw, Selvage and other hitches are often used.

11. To drag a barrel or cylindrical object up an incline—Parbuckle, Fig. 45. The purchase can be increased by using a double block or multiple block (*see* para. 17), and passing the rope additional turns round the cylinder.

Cordage.

12. The size of a rope is denoted by its circumference in inches; its length is given in fathoms (a fathom is 6 feet). For field purposes, the safe working load for all cordage has been laid down as C2 cwts. where C is the circumference in inches, while for steel wire rope it may be taken as 9 C2 cwts. Steel wire rope may be taken as twice as strong as iron wire rope.

13. The strength of wire varies greatly; as a very rough rule it may be taken that the breaking weight in pounds equals three times the weight per mile in pounds. Steel wire may be taken as about twice as strong.

14. The strength of a lashing round two objects may be taken as four-fifths of the number of times the lashing passes from one object to the other multiplied by the unit strength of the lashing, *e.g.*, a square lashing with four turns has a holding power of $4/5 \times 16 \times$ strength of lashing; in the case of a hook lashed to a spar with four turns it is $4/5 \cdot 8 \cdot$ strength of lashing. When using wire in lashings multiply by three-fifths instead of four-fifths.

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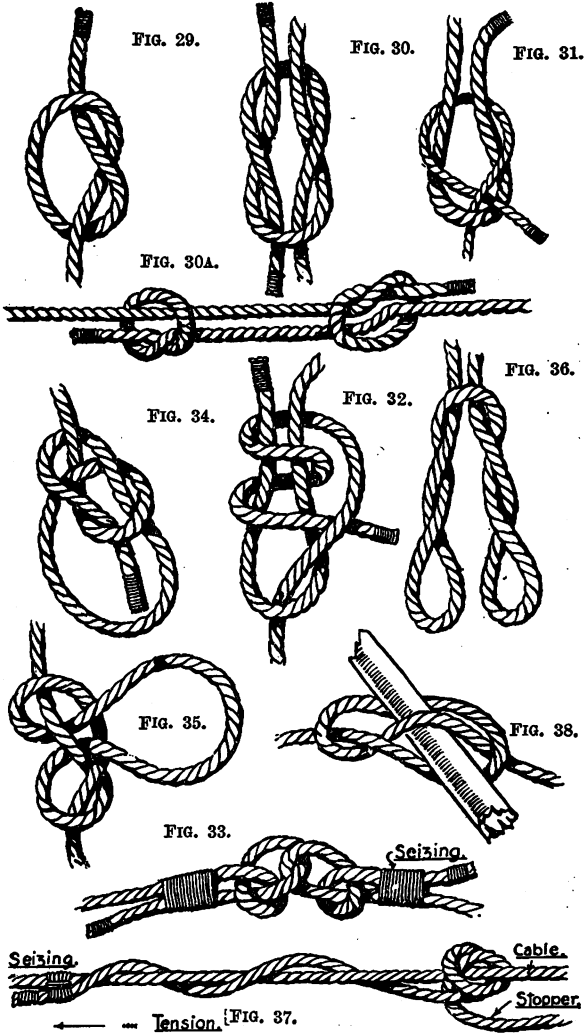

Fig. 37.

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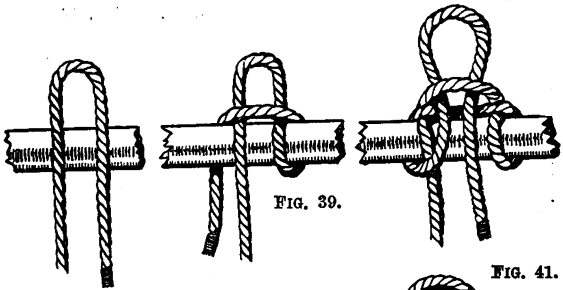

FIG. 39.

FIG. 40.

FIG. 41.

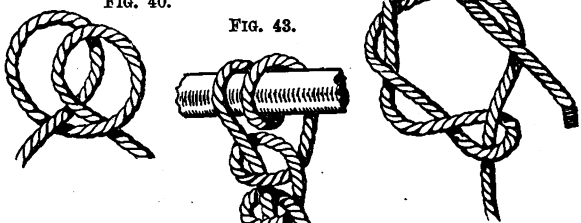

FIG. 43.

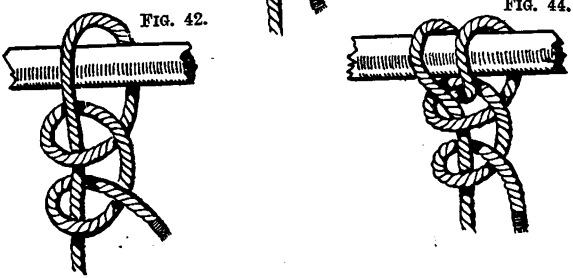

FIG. 42.

FIG. 44.

Lashings.

16.—(*a*) Rack-lashing, consisting of an 8 ft. length of rope with a pointed stick at one end. Figs. 48 and 49.
(*b*) Square lashing. Fig. 50.
(*c*) Diagonal lashing. Fig. 51.
(*d*) To lash a block to a spar. Fig. 52.
(*e*) To sling a spar. Figs. 53, 54 and 55.

Slings.

17. Slings are made of rope, wire or chain. Rope slings are made by splicing the ends of a rope together. To sling a bomb, or to form an attachment for the hooks of tackles. Fig. 56.

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FIG. 46. FIG. 47.

FIG. 45.

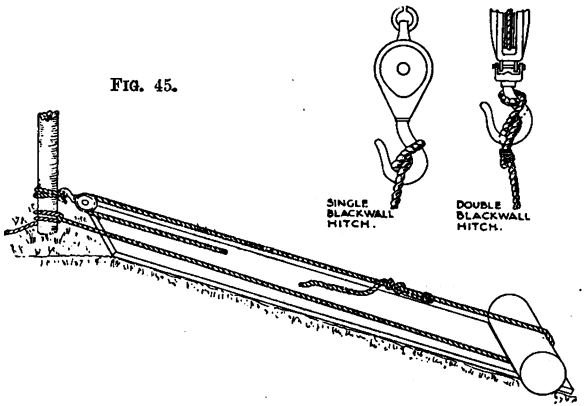


FIG. 48. FIG. 49.

RACK LASHINGS.

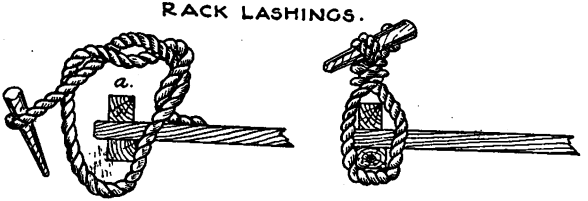
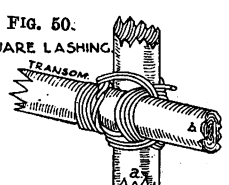


FIG. 50. FIG. 51.

SQUARE LASHING.



DIAGONAL LASHING.

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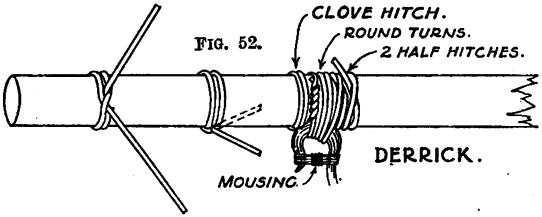

FIG. 52.

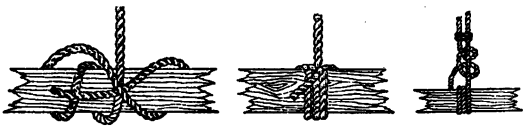

FIG. 53. FIG. 54. FIG. 55.

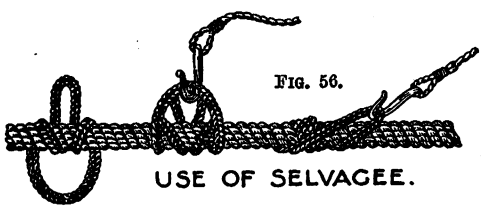

FIG. 56.

Blocks and Tackle.

18. Blocks are used for the purpose of changing the direction of ropes or of gaining power.

They are called single, double, treble, etc., according to the number of sheaves which they contain. The sheaves revolve on a pin, which should be kept well lubricated. Snatch blocks are single blocks with an opening in one side of the shell, to admit a rope without passing its end through. This opening is closed by a hinged strap. The rope with which tackles are rove is called a fall. To overhaul is to separate the blocks. To round in is to bring them closer together. When brought together the blocks are said to be chock.

In using tackle care must be taken to prevent its twisting.

In any system of two blocks, if P be the power required to raise a weight W, G the number of returns at the movable block, and N the total number of sheaves; then

$$P = \frac{W}{G} + \left(\frac{N}{10} \times \frac{W}{G}\right)$$

Methods for using blocks and tackles and snatch blocks for changing direction of pull are shown at Figs. 57–66.

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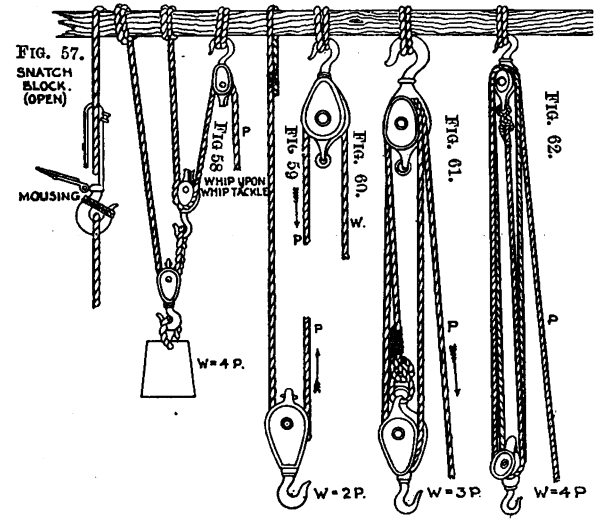

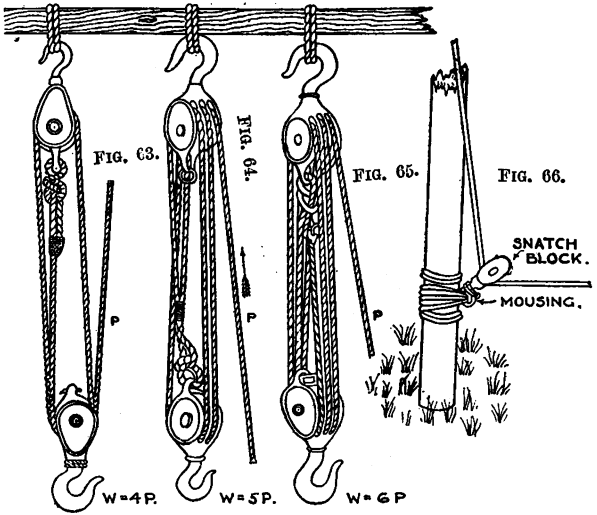

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16. FIELD ENGINEERS' TOOLS AND THEIR USES.

	Weight.	Length.	Use.
Entrenching Tools.	Lbs. Ozs.	Ft. In.	
Pickaxes - - -	8 0	3 0	For loosening soil—the pointed end for use in hard ground, the chisel end for use in soft ground.
Shovels, G. S. - -	3 8	3 1	For clearing away soil loosened by the pick.
,, R. E. - -	5 0	3 4	
Spades - - -	5 10	3 2	For cutting sods and excavating in soft soil.
Entrenching implements.	—	—	For excavating in exposed positions.
Cutting Tools.			
Felling axes - -	6 7	2 8	For felling timber.
Hand axes - -	2 3	1 4	Clearing brushwood, trimming, etc.
Bill hook - - -	1 13	1 3½	Clearing brushwood, trimming, etc.
Hand saws - -	5 6	2 2	Clearing brushwood, trimming and cutting scantling.
Cross cut saws - -	6 7	5 0	For felling timber.
Reaping hooks -	1 0	1 6½	Cleaning brushwood, etc.
Folding saws (complete).	1 12	—	For felling timber.
Wire cutters - -	1 4	9½	
Crowbars - - -	12 0	3 6	For breaking ground or for use as levers, etc.
Mauls - - -	14 0	—	Driving pickets, etc.

Notes.—Felling axes should not be used for felling timber unless men specially trained to use them are available, otherwise the cross-cut saw is safer and easier. When the saw is used for felling, wedges are required to keep the saw from jamming.

When felling trees, advantage should be taken of the natural inclination of the tree out of the perpendicular. If this is not perceptible, guy rope can be used to strain the tree in the direction it is desired to fell it.

When picks and shovels are to be used, spare helves for picks and spare shovels should be available, and grindstones, saw-setts, files and honing stones are necessary when cutting tools are in use.

All tools should be kept clean; cutting tools should be well-greased when not in use.

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TABLE OF TIME, MEN AND TOOLS.

Required for the Execution of Certain Field Works.

Except where otherwise stated the material and tools are assumed to be on the site of the work. All tracing and marking out is to be done before the distribution of the working parties at the sites. Not more than five minutes should be consumed in distributing the men, or in changing reliefs, if the men have been told off into suitable groups or parties under leaders previously instructed in the nature of the particular works in hand. One leader or foreman can conveniently supervise up to 20 unskilled men on earthwork.

No.	Nature of Work.	Minutes of one Man.	Per Unit of Task.	Suitable Unit Party	Tools per Party.	Remarks and Notes.
1	ENTRENCHING. Excavation only -	3	1 cubic ft. -	1	1 shovel and 1 pick -	Average over a relief of 4 hrs. in ordinary easy soil— Volume excavated in cubic feet; average hourly rates.
2	Shovelling loose earth	1	1 cubic ft. -	1	1 shovel - -	Earth removed or scattered by other men (*see* items Nos. 2 and 3). If tools are double manned and first pair relieved after 2 hours, time can be reduced to 150 minutes. As into barrows, boxes, gabions, stretchers, sacks, etc., or cross lifting or spreading carefully. Averaged over 8 hours work.

—	1st hr.	2nd hr.	3rd hr.	4th to 8th hr.
Tools used by one man	30	25	15	10
Tools double manned -	40	33	20	13

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3	Removing 50 yards (average) deposit and return.	1 2	1 cubic ft. - 1 cubic ft. -	1 1	1 barrow - - 1 stretcher - -	2 cubic feet per load. Average weight of earth or sand 1 cwt. per 1 cubic foot. Removing earth over 100 yards is usually more economical by horse and cart, or tram.
4	Filling sandbags -	3	1 sandbag -	3	2 shovels - -	Averaged over 2 hours' work, *i.e.*, 120 bags filled by 3 men. Size up to 20 in. × 10 in. × 5 in. Weight 60 lbs. For sacks use item No. 2. Corn sacks average 2 bushels = 2½ cubic feet when quite full. Allow 1 cubic foot only.
					Revetments.	
5	Sandbag or sack -	3	1 sq. ft. -	2	—	Sandbags (already filled) in course of alternate headers and stretchers. 1 sack or 2 bags per 1 sq. ft.
6	Fascines, making -	240	1 fascine -	4	3 billhooks, 2 knives, 1 handsaw, 1 maul, 1 pair pliers, 1 choker.	Materials: 200 lbs. brushwood and 60 ft. of wire or hoop iron (40 ft.) per fascine, 18 ft. long by 9 in. diameter. Weight complete, about 140 lbs. Cradle for making requires 10 pickets, 6 ft. 6 in. by 3 in. diameter.
	Cutting and Felling.					
7	Trees, felling - -	1	1 in. of diam.	1	1 felling axe, or saw	Over 12 ins. diameter allow time in minutes = $\frac{d^2}{144}$ where d = mean diameter in inches. If only hand axes are available, allow twice the time as calculated by both these rules.
8	Woods, clearing of brushwood and small trees.	2½	1 sq. yard -	20	10 billhooks, 4 felling axes, 2 hand axes, 2 saws, 1 grindstone, 2 whetstones.	All hands felling at first; then a proportion detailed for collecting and removing according to purpose in view. Produce: about 5 lbs. brushwood per 1 square yard.
9	Hedges, felling stems -	10	1 yd. run -	2	1 billhook or handaxe, 1 saw, 3 fathoms rope.	Average stiff thorn up to 2 in. diameter. If necessary use rope to expose lower stems to the cutting tool.

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Table of Time, Men and Tools—*continued.*

No.	Nature of Work.	Minutes of one Man.	Per Unit of Task.	Suitable Unit Party.	Tools per Party.	Remarks and Notes.
	OBSTACLES.					
10	Abatis, and wired -	120	1 yd. run -	20	As for item 23; also 2 mauls, 3 pair pliers, 1 pickaxe, 1 shovel.	1 strong row. The material must be close at hand. Allow 20 yds. wire per run per row. The length of the branches is more important than their size. Wire each butt securely to a separate stout picket driven at least 2 feet into the ground. Wire for density near the ground.
11	Wire entanglements -	30	1 sq. yd. -	3	1 billhook, 1 handsaw, 1 maul, 1 pair pliers, 1 pair wire-cutters, 3 rag pads for gripping and straining wire. In hard ground add: 1 steel jumper, 1 sledge hammer.	Materials: 1 stout post 5 to 9 ft. long by 5 to 6 in. diam. per 4 sq. yds. of obstacle. 1 stout picket 2 to 8 ft. long by 5 in. diam. per yd. run of finished obstacle, for side stays. 12 to 18 yds. of wire per 1 sq. yd. of finished obstacle. *N.B.*—A very formidable obstacle can be made with three stout posts, 1 stout picket, and 150 yds. wire per yd. run complete. Barbed wire is most quickly handled and fixed if issued in lengths of about 10 ft. when issued in entanglements.

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17. AERODROMES AND SEAPLANE BASES.

AERODROMES.

Classification of Aerodromes.

1. Under active service conditions aerodromes may be classed broadly into two categories :—

Class (*a*) Those in use against a civilised enemy.
Class (*b*) Those in use against an uncivilised enemy.

2. Class (*a*) Aerodrome will generally be liable to aerial bombing attack but comparatively free from infantry attack, and will normally be situated well in the rear of the front line.

3. Class (*b*) Aerodrome, on the other hand, will be subject to land attack and free from aerial attack.

4. The general arrangement of aerodromes falling under these two classes will therefore differ materially in such important matters as position of aerodromes, lay-out of buildings, and measures for defence. These points will be dealt with in detail subsequently.

Selection of Site.

5. The site selected for an aerodrome is of extreme importance as it affects initial cost, running charges, and suitability for offensive and defensive operations.

6. For both class (*a*) and (*b*) aerodromes, the following general principles should be borne in mind in selecting a site, the factors of major importance to receive consideration being

(*a*) Flying facilities.
(*b*) Access.
(*c*) Habitation.

7. The site should provide the best possible flying facilities of which the locality is capable. It should therefore, where practicable, be sufficiently remote from hills to avoid dangerous air currents, should be surrounded by open country to render forced landings safe in most directions especially against the prevailing wind, and at a safe distance from woods, ravines and water surfaces. In the selection of a site, disturbance of agriculture should be avoided as far as possible.

8. In Class (*a*) aerodromes within areas liable to aerial attack, every effort should be made to select sites in positions difficult to locate from the air, especially with relation to conspicuous features, such as rivers and other water surfaces, well defined woods, road inter-sections, railway junctions, or any objects readily indentified from the air, the proximity of which should be avoided as far as possible.

9. The site seleced, whilst securing as far as circumstances permit the inconspicuous position indicated above, should be within reasonable access of good roads suitable for motor traffic and if possible within touch of a railway, preferably a branch line. Internal roads and approach roads to the aerodrome should be rendered as inconspicuous as possible by such expedients as tarring or other camouflage treatment.

10. The site should be as healthy as possible, with a suitable water supply available and facilities for the necessary sanitation.

11. For Class (*b*) aerodromes, the same general principles as apply to Class (*a*) aerodromes should be borne in mind in the selection of a site, though access from road or rail and defence considerations are of relatively greater importance than invisibility from the air.

Road Access.

12. Where there is no special need for concealment, access roads should be sited on high ground, but where it is necessary to cross marshy land, water courses, etc., special care must be taken to see that the roadways are kept in good order.

13. Roads should present a hard surface for traffic. This can be obtained by using hard stone or broken bricks for bottoming, and covering

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with cinders or gravel. For temporary purposes, cinders or gravel laid on the surface of hard ground and consolidated as much as possible, may be used, the roadway being kept well drained.

14. The best foundation for a temporary road over boggy ground is one or more layers of fascines or hurdles; the top row must lie across the direction of the traffic, touching one another. When time is short or suitable material is not at hand, much can be done by throwing down brushwood, heather or even straw or grass laid across the road. It is quite useless to place stones or earth in small quantities upon a yielding foundation.

15. Where timber is available and heavy traffic is expected, a "Corduroy" road may be made by felling trees, and laying them across the road at right angles to its direction, ribands being spiked to them at either end; or alternatively the logs may be held together by interlacing with rope or wire. The interstices between fascines, brushwood, logs, etc., may be filled with small stones, and earth to make a better surface.

16. A roadway 10 feet wide (8 feet minimum) will take a single line of wagons passing in one direction, or infantry in fours; 12 feet is better for allowing horsemen to pass without difficulty; for each additional line of vehicles 8 feet should be added to the width of the road. A width of 6 feet is sufficient for infantry in file or pack animals moving in one direction. Gaps in walls, hedges, etc., forming road boundaries should be made at least 15 feet wide if intended for wheeled traffic.

17. Roadways may be formed over ditches and water courses by the following methods :—

(*a*) Where there is not much flow of water the water courses may be filled with fascines covered with earth.

(*b*) Where there is a constant flow of water, they may be filled with boulders which will allow the water to run through, the boulders being covered with smaller stones graded down to form a surface through which earth will not pass.

(*c*) The water may be carried through box drains composed of planks nailed together in the form of a box with open ends. The box drain to be placed longitudinally in the water ways, one or more being provided as required, and the ditch filled in round and over the boxes with earth.

(*d*) Barrel drains may be used for the same purpose. Barrels with the ends knocked out are placed longitudinally in the water course, butting against each other so as to form a culvert. The ditch is then filled in, round and over the barrels, and at least 3 feet of earth placed over the barrels to prevent crushing.

(*e*) For larger openings, bridges should be provided as described in Section 21. Care should be taken to keep the entrance to the drains clear of weeds, rubbish, etc., otherwise such obstructions may cause the water to bank up, and carry away the culvert.

Landing Area.

18. For both classes of aerodromes the actual landing area should provide a clear run of approximately 600 yards in the principal landing directions due to prevalent winds. No obstructions within the flight approach to the landing area should project above an imaginary plane surface rising from the edges of the landing area at a gradient of 1 in 16, which allows a reasonable margin of safety on either the climbing or gliding angle of normal type aeroplanes.

19. Where obstructions cannot be removed or reduced to fall below this imaginary plane surface, the landing area should be shifted back to provide the necessary unobstructed area, or where this cannot be arranged, flight gaps about 200 yards wide should be provided.

Air room and freedom from obstruction with facilities for making forced landings are of greater importance to aeroplanes leaving the aerodrome than to those entering it, and the site selected should, therefore, provide the fewest obstructions and the best facilities for forced landings in a direction from which prevailing winds blow. Generally speaking, high ground is preferable from most points of view.

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20. Where ground suitable for landing areas is restricted, the length of run and angle of approach may be reduced for light types of aeroplanes according to their class and function.

21. The landing surface of aerodromes should be fairly level, or of a rolling character, free from sharp changes of inclination, ridge and furrow, and ditches or mounds liable to cause an aeroplane to jump whilst taxi-ing. The surface should be well drained and sufficiently solid to take the weight of large aeroplanes; where possible, it should be laid down in permanent pasture. Where pasture cannot be grown, surface soil can be bound by such expedients as watering and rolling.

Drainage.

22. Porous soil with good natural drainage is most suitable for producing a good landing surface. Ground subject to fog or mist and liable to become water-logged during wet weather or rainy seasons should be avoided, careful local enquiries being made to determine this. Where natural drainage is insufficient, land drainage is essential. The natural fall of the land should be ascertained and the land drains should follow the depressions and be led to ditches outside the area of the flying ground. Shallow ditches filled with broken brick or fascines, and covered over and turfed, will serve the purpose if agricultural drain pipes cannot be obtained. Branch drains should be led to the main line of drains where necessary.

Levelling.

23. Mounds or ditches on the flying ground should be levelled and re-turfed. Any declivities in a flying ground caused by the grubbing and removal of internal fences are best filled up with soil; cinders on no account should be used. Ditches should always be piped (with pipes of sufficient size to take the normal flow of water) before being filled up. Any depression caused by subsidence afterwards can be remedied by excavating a certain amount of soil; bundles of faggots can then be laid in and the soil replaced and well rammed.

24. When the selected site is under ridge and furrow, it is bad policy to plough up the land with the intention of levelling, as land so treated still retains its undulations after the completion of the usual operations.

The most satisfactory although somewhat costly method of treating such land is as follows:—

(*a*) Strip, with a turf plough or skimmer, the turf between the centre of one ridge and the next ridge on each side of alternate furrows in the field (the turf should not be less than 2 inches thick) roll up in convenient lengths and transfer to the alternate strips not yet skimmed.

(*b*) Commencing from the furrow in the middle of the stripped portion, leave unploughed a strip of the width of two slices and then open a very shallow furrow on each side, turning each slice towards the centre and gradually increase the depth of the furrow until at each original ridge it attains to the depth desired, say at the most 8 inches.

(*c*) When the ploughing of the strip is completed, hand labour should remove the ploughed soil, care being taken to throw sufficient into the furrow to allow for subsidence through consolidation; this can often best be done by means of strong drag hoes or rakes. Finally, before re-placing the turf, the surface should be horse-harrowed and rolled (the latter if not too wet).

(*d*) The operation should then be repeated on the other alternate strips which have not yet been touched.

(*e*) When the area is completed, it should be rolled three or four times to ensure the turf properly knotting.

Grass Cutting.

25. Grass in the vicinity of buildings should be cut periodically for avoidance of fire risks.

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26. To keep grass short on the flying ground arrangements should be made with local farmers, etc., for grazing the land. If this is not practicable, the grass on parts of the flying ground most in use should be cut periodically.

Precautions against Heath Fires.

27. The utmost care must be exercised to prevent fires from starting on heaths, commons, or moorlands :—

(*a*) Lighted matter, particularly cigarette ends and matches, must not be used by personnel in the neighbourhood of or when crossing the above.

(*b*) Constant watch should be kept to stamp out any incipient fires. In the event of a fire breaking out it should be attacked at once to prevent spreading. A fire which can be readily stamped out by a few men if attacked at once, may easily get beyond control if left for a few minutes.

(*c*) No glass bottles should be left about on any part of a heath, common or moor, as a fire is often started by the sun's rays striking through them.

Obstacles.

28. Trees in the vicinity of landing grounds should be felled.

29. If surrounding hedges are too high they should either be reduced by layering (laying) or cut to a height of 3 ft. 6 in.

30. Where wire fences are used, the top wire should be covered with strips of sacking so that the fence may be easily distinguished from the air.

Lay-out of Buildings.

31. The lay-out of buildings is materially different for class (*a*) and (*b*) aerodromes, chiefly on account of the difference in their vulnerability to different forms of attack.

32. In aerodromes liable to aerial attack, the hangars and technical buildings should be staggered, dispersed and placed in as inconspicuous positions as possible, on the flanks of the principal landing area, and therefore at right angles to the direction of the prevalent wind, so as to leave the "take off" into this wind as free as possible. Easy access should be provided between hangars and aerodromes.

33. Workshops should be within reasonable reach of hangars though separated from them by sufficient distances to minimise liability to damage by bombs.

34. The position and arrangement of living quarters must be considered in connection with the nature of the attack to which the aerodrome is considered to be liable.

If exposed to aerial attack, it is desirable that these quarters shall be as far away from the aerodrome as considerations of convenience permit, and sited and arranged so as to be as inconspicuous as possible and away from the line of attack. Sometimes advantage may be taken of adjacent woods to conceal living quarters.

On the other hand, if exposed to unexpected land attacks, it is desirable that the sleeping quarters should be as close as possible to the hangars in which the machines are stored, and to the technical buildings, as the protection of these is the essential part of the defence. The protection of the sleeping quarters of the squadron from destruction by an attacking party is a secondary consideration, and it is important to keep the dimensions of the defended area as small as possible. The living quarters can, therefore, be excluded from this area when it is considered more convenient to do so.

Water Supply.

35. Where a supply can be obtained within a reasonable distance either by sinking a well, or tapping a spring, it is desirable to install a power driven pump and provide a piped supply to the aerodrome. Where, for any reason, this arrangement is not practicable, it will be necessary to arrange to cart the water required. An adequate supply can, however, only be provided conveniently by means of pipes, and it is very desirable,

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whenever at all practicable, to adopt this arrangement, and to bear this requirement in mind when selecting aerodrome sites. The quality of the water should be the best obtainable. If not found fit for drinking, as obtained, it will have to be treated by chlorination or otherwise under the directions of the Medical Officer.

Sanitation and Drainage.

36. Normally, bucket latrines and disposal of soil by incineration, or burying, will be adopted for aerodromes established under active service conditions. Sullage water will normally be disposed of by soak pits, if the ground be sufficiently porous to admit of this method of disposal. On heavy clay or other non-porous soils, the method of soak pits will be found impracticable, and in these circumstances some method of drains, or open channels, must be devised for conveying away the sullage water to points where it can be disposed of by distribution over the surface of the ground without causing a nuisance. In the case of cookhouses, bath-houses and other places, which produce sullage water in any quantity, this will generally entail siting them in positions selected with a view to facilities for drainage. It is to be borne in mind that the more water supplied to a camp, the more there is to get rid of, and when disposal is a difficulty, a remedy often lies in reducing the consumption within the limits of the camp, and transferring ablution places to positions outside its immediate area.

Petrol Supply.

37. Petrol in the field will usually be supplied and stored in barrels or portable containers of less capacity. Bulk petrol installations will seldom be justified except where a very considerable degree of permanency can be foreseen for an aerodrome.

Defence.

38. The defence requirements should be carefully considered and co-ordinated with those of any other military forces with which the R.A.F. may at the time be co-operating.

As a general rule, when liable to aerial attack it is desirable that not more than two squadrons should operate from any one aerodrome, as the greater the number of units, the larger and more conspicuous does the target become.

39. In Class (*a*) aerodromes, it is important to protect the machines from damage by splinters from bombs, and to effect this as efficiently as practicable, the hangars should be surrounded by parapets 6 or 8 feet in height, as described in Section (19).

In Class (*b*) aerodromes, a series of machine gun posts should be arranged in suitable positions to cover all the ground round the hangars and technical buildings, and to support each other. These should be connected by some kind of defensive parapet, which would also serve as a covered way for communication and support.

If both air and land attack has to be guarded against, the parapets for protection against splinters from bombs should be arranged so as to serve also for infantry defence.

Seaplane Bases.

Locality and Size.

40. The site should, if possible, be in the immediate vicinity of sheltered water of about a square mile in area, protected from the prevailing wind, and as far as possible free from tide, breakers and dangerous cross currents, with a foreshore neither too flat nor too steep. A site surrounded by high hills is undesirable.

41. Suitable anchorage for mooring motor boats and seaplanes should be provided.

Lay-out.

42. The arrangement of buildings suggested above in the case of aerodromes applies generally to the case of seaplane bases.

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43. Slipways should be not less than 40 feet wide; the surfaces should, if possible, be concrete—without rails—sufficiently strong to support the type of machine to be used and its trolleys, and curbs should be provided at sides and seaward end. The incline should, if possible, be not greater than 1 in 10, or less than 1 in 15. The minimum amount of water required to float a seaplane off its trolley is 6 feet. The depths of water available must be investigated and the range of tides considered. It is not considered essential to provide slipways for hauling in seaplanes at dead low water of spring tides; slipways with about 7 feet of water over seaward ends at mean tide level will generally meet requirements.

44. The provision of gangways to assist in the handling of seaplanes when floating on to trolleys is desirable where cross currents are severe, and space for construction of gangways should be left free for use if ultimately found essential. The clear width between gangways in such cases should be approximately 200 feet.

45. Technical accommodation should be situated close to the foreshore, so that access to the sea by means of aprons and slipways is readily obtainable.

46. The remarks made above under "Acrodromes" regarding water supply, sanitation and drainage and defence apply generally in the case of seaplane bases.

18. ERECTION OF HANGARS.

Bessonneau Hangars.

Transport.

1. Transport required to remove one Bessonneau type "H" hangar, 66 ft. 3 in. × 79 ft. inside canvas, including canvas covers and plant for erection—three 3-ton petrol lorries with trailers.

Weight approximately 8½ tons.

Erection Plant.

2. Required:—

(i) 1 pair 15 cwt, pulley blocks preferably 3 and 2 sheave.
(ii) 1 snatch or single sheave block.
(iii) 1 hemp or manilla fall rope, 3 in. circumference—200 ft. long.
(iv) 4 lengths hemp or manilla rope, 3 in. circumference, 100 ft. long.
(v) 1 doz. 18 ft. scaffold ties.
(vi) 1 derrick 30 ft. high to lift 15 cwt.
(*Note.*—A stout scaffold pole, say 4 in. diameter at the top, is suitable for this purpose. If not available, a suitable ladder may be used, or failing this, three of the upright gable-end framing bars of "T" Section may be bolted together and used as a derrick.)
(vii) Spanners, ⅜ in., ½ in., ⅝ in., and ¾ in.
(*Note.*—Three each of the latter should be available for use. These spanners are included in the boxes of bolts supplied with a new hangar.)
(viii) 2 pickaxes.
(ix) 2 shovels.
(x) 1 measuring tape.
(xi) 1 builder's line.
(xii) 1 carpenter's kit.
(xiii) 1 spirit level, and
(xiv) 1 plumb rule.
(*Note.*—The last five items are not essential, but will materially assist the work of erection.)

Selection of Site and Setting Out.

3. A level site should, if possible, be selected. Where this is not possible, care should be taken to see that the longitudinal line for each set of side framing is as nearly level as can be arranged.

4. When erecting on unlevel ground, it is essential that the lay-out is such that the structure as finally erected stands on a plane surface, *i.e.*, there may be a slope on the cross section of the lay-out and also a

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slope on the longitudinal section of the lay-out, but these slopes must be parallel in so far as the two ends and two sides respectively are concerned.

5. It may be necessary, in order to secure the above conditions, to pack up under the sole plates of the uprights or excavate trenches under them. The maximum variation between each set of side framing or end framing should not exceed 3 inches, as any excess over this figure causes a resultant excessive strain on the lower struts. If absolutely unavoidable, additional struts on the lower side and guys on the higher side should be introduced.

6. It should be remembered when erecting on uneven ground that the uprights, etc. will not be plumb, but should be allowed to stand at a right-angle to the line of cross section or longitudinal section. If this arrangement is not adhered to the framing, cross-bracing, etc., is unduly strained at some points and carries no load whatever at others.

7. In fixing the position of the hangar the line of one set of side framing should be determined and set out; the necessary right angle should then be measuring in multiples of 3, 4 and 5.

(*Note.*—If 66-ft. tape is available, the lengths 15, 20 and 25 can be taken for this purpose. In this way the four corners of the building can be marked with pegs and as a final check the diagonals should be measured with a tape or line in order to check that they are of the same length.)

Erection and Assembling.

8. This should be carried out in the following order :—

(i) Side framing.
(ii) Trusses and purlins, starting from No. 7 truss, closed end to No. 1 truss, door end.
(iii) Canvas.

(*Note.*—Diagrams showing all details are enclosed in the bolt boxes.)

9.—*SIDE FRAMING:* Loosely bolt the triangular iron brackets to upright members of side framing.

Note 1.—Two of these brackets will be found with one hole drilled in the diagonal side; these holes take the door curtain operating gear and consequently these brackets should be fixed on the uprights supporting No. 1 truss.

Note 2.—The connecting bolts for these brackets on uprights No. 7 and No. 1 vary from these on the intermediate truss, being supplied with an eye to which the wire corner guys are made fast.

Erection should be commenced on one side starting with No. 7 upright. All uprights are of similar construction with the exception that the No. 7's have slots cut in the flange of the "T" to receive the cross bracing from back end framing. As each upright is erected the cross bracing (flats) and horizontal rails should be fixed. When the whole of one side has been erected the work should be lined up and levelled by boning between the corner posts. The erection of the opposite side should follow on. This side should only be roughly lined up and levelled as it has to be adjusted to the roof trusses at a later stage.

10. *ROOF TRUSSES:* Each complete truss is delivered in four sections, which should be assembled on the ground, joint plates of channel section and necessary bolts being supplied for this purpose. In order to ensure uniformity when assembling, care should be taken to arrange that the cover plates over the struts are all kept to the same side, *i.e.*, either to the top or bottom as the truss lies on the ground.

These cover plates will be observed to be on one face only of each section of the truss. Trusses Nos. 1 to 7 are similar in construction with the following exceptions :—

Truss No. 7 is holed through the tie to receive bolts from the connection plates at the top of the uprights forming the end-framing.
Truss No. 1 is also holed through tie to receive the door curtain runways.

These two trusses, Nos. 1 and 7, are easily distinguishable, as in No. 1 the bolt holes are evenly spaced in pairs at approximately 3-inch intervals,

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whereas in No. 7, bolt holes are in groups of four at approximately 12-ft. intervals.

Before lifting the trusses, the flat iron plates to which the purlins are secured should be loosely bolted in position.

The trusses should be lifted by means of the derrick which should be rigged for the erection of No. 7 truss first, the pole being kept on the inside of the truss so that it can be moved back to No. 6 truss without being lowered to the ground.

The four 100-ft. ropes should be used to provide guys for the derrick, two fore and two aft; the 200-ft. fall rope should be reeved into the 2 and 3 sheave blocks, the 3 sheave block being lashed to the top of the derrick.

(*Note.*—A small timber packing 2-inch to 3-inch wide should first be lashed to the top of the derrick to form a cat-head to keep the tackle clear of the pole.)

The lead from the tackle should be taken through the single sheave or snatch block which should be lashed to the foot of the derrick.

The screw pickets supplied for fixing the side framing, curtains, etc., can be used for guy anchorages. When No. 7 truss is lifted into position the shoes should be bolted to the brackets on the side framing, and the long back raker from the centre of the truss to ground level should be hoisted and secured before the tackle is released. The truss should be adjusted so that it stands plumb to the line of the accepted longitudinal section and the derrick moved back to lift No. 6 truss. When No. 6 truss is erected several purlins and sections of the diagonal bracing from No. 7 truss should be fixed, when the derrick may be released and moved back to No. 5 truss and so on.

A small party of men can follow on completing the fixing of purlins, cross bracing, common rafters, end framing, etc.

11. *CANVAS COVERS:* Canvas Covers are supplied as follows:—

1 marked "left-hand side sheet."
1 marked "right-hand side sheet."
1 marked "rear gable end sheet."
1 marked "front gable end sheet."
2 roof sheets marked "front" and "rear," *i.e.*, roof canvas is supplied in two halves.
2 door curtains marked "left-hand" and "right-hand" respectively.

Side sheets should be fixed in place and then rear gable end and front gable end sheets. In getting the roof sheets into position the canvas should be laid out on the ground to one side of the hangar, right side up, four ropes should be lashed at even intervals to the derrick which should be laid on the canvas and rolled up in it, when it will be noted that the four above-mentioned ropes roll round the derrick at the same time. The roll is then hoisted by hand up to the eaves level with the trusses; the four ropes are passed over the roof and when pulled out the curtain will be found to unroll over the rafters in somewhat the same way as a blind unrolls. This action is taken with each half of the roof canvas and when finally adjusted the two sheets are lashed together, lacing and eyes being provided for this purpose.

The fixing of door curtains follows the roof covering.

12. *GENERAL.*—Before putting up canvas see that all wire guys are fixed. These should be released and threaded through the canvas one by one as the latter is put on. The long guys with quick release shackles are provided for the door end.

When bolting up work always select the shortest bolt which will fulfil the purpose. If this action is not taken it will be found towards the end of the work that the remaining bolts are not sufficiently long for the purpose required.

The bolts vary in length for different joints by less than ½ inch. This point should receive close attention.

A working party of 20 forms a very suitable number for quick erection, but more or less can be employed according to the time available. A party should always be employed assembling ahead of the erectors, who should again be followed by a party filling in framing, purlins, etc.

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It should not be necessary to drill any new holes if the parts are selected with discrimination; such action only weakens the structure and complicates future erection. Parts are numbered as shown on the diagrams in bolt boxes, but these numbers are generally found to be illegible in the case of sheds which have previously been erected on another site.

Maintenance.

13. The following points should receive careful attention in order to preserve the structure and canvas :—

(i) See that guys are always well secured and picket anchorages screwed home.

(ii) The detachable guys at front end should, in a high wind, be replaced as soon as machines have been taken in and out of the hangar. They should always be fixed when the hangar is closed up.

(iii) Canvas should not be allowed to flap, as in this way it is easily damaged. All lashings, etc. should be properly secured and those which break away should be repaired immediately.

(iv) Drain grips should be cut round the hangar, immediately below the side and end coverings.

(v) In a high wind, bags of sand or earth placed on the sole plates of uprights will steady the structure.

(vi) Damage to canvas should be repaired without delay.

(vii) Stores in the hangars should be stacked well clear of the canvas.

Dismantling.

14. This should be tackled in the same way as erection, care being taken to collect and bundle all plates, anchor pickets, etc., and box all nuts and bolts. Nuts should be put back on to their respective bolts. If a bolt has to be driven out care should be taken not to damage the thread. Bolts and nuts should be dipped in oil before packing.

If possible the canvas should be removed when absolutely dry and should be bundled and stacked on packings, clear of the ground.

If it is unavoidably rolled into bundles when damp, the officer to whom it is handed over should be advised of the fact, so that the first opportunity can be taken of opening out and drying.

Removable parts, such as brackets or uprights, purlin cleats, etc., should always be taken off as they increase bulk for transport purposes and are likely to cause damage.

Hervieu Hangars.

Transport.

15. Transport required to move one Hervieu hangar, size 89 ft. × 100 ft. —5 three-ton lorries and trailers.

Erection Plant.

16. If the hangar is delivered complete in all details as supplied by makers no actual erection plant is required, but a tape, two pick-axes, two shovels and a carpenter's kit will be found to be useful.

Selection of Site.

17. As for Bessonneau.

Erection.

18. A very complete diagram showing the system of erecting the hangar is sent out with each shed. The work should be started by the erection of one side which can be set to its correct position. The other side should be erected 2 ins. farther out than as finally fixed. This action is taken in order to enable the complete roof to be assembled inside of the side framing. When side framing has been erected, the roof complete with canvas is built up at ground level, the shoes at one end of the trusses being laid in the cradles fixed to the uprights on the side first erected. These cradles, it will be noted, are coupled to small winches. On the opposite side the wire tackle which is used for raising the cradles should be tem-

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porarily uncoupled and secured to the shoe of each truss; the trusses can then be lifted approximately 18 ins. when the uprights can be slipped into place and the trusses lowered into the cradle as on the side first referred to. When the ends of all trusses are housed in the cradles on either side the whole roof should be raised into position by means of the winches on each upright.

The wire guys on side and end framing should be carefully fixed prior to lifting the roof into its final position.

Canvas.

19. The side and end canvas is attached to the roof canvas and goes up with the roof. When roof is erected this canvas is rolled down into final position. The covering is divided into three sections which with two door curtains makes a total of 5 pieces.

General.
Maintenance.
Dismantling, etc.

As for Bessonneau.

19. PROTECTION AGAINST BOMBS.

Protection of Hangars.

1. It is not practicable to protect hangars completely against aerial attack, but damage from splinters, small bombs, etc., may be localised by the provision of traverses or walls.

2. Along two sides and back, traverses or walls of double corrugated iron, with sand or earth between, as shown at Fig. 67, should be provided. The sheeting should be laid inside pairs of stout stakes or poles 3 ins. to 4 ins. diameter, placed about 3 feet apart and driven into the ground about 2 ft., the tops of each pair being connected at the head by a piece of stout board nailed on and the corrugated iron walls also wired together at intervals. These traverses should be about 14 ins. wide at the top with a base of about 1 ft. 4 ins. The walls can also be carried across a portion of the front of the hangars, leaving sufficient opening for the passage of aeroplanes. Fig. 68.

3. The opening in the front wall may be protected by narrow gauge wagons (Decauville type) kept in reserve at each side of the opening and run across on a 2 ft. gauge track, on an alarm being given. These wagons should be coupled closely together. If flat wagons are used they should be loaded with large packing cases filled with earth and longitudinal baulks should be bolted to the under side of the frames so as to leave as little opening as possible for shell splinters to pass. If tip wagons are used, steel sheeting may be hung to the sides of the wagons so as to form a continuous curtain, and the tip wagons filled with earth.

4. If the size of the aeroplanes will permit, traverses of the same type as the external walls may be constructed inside the hangars.

Protection of Tents and Huts.

5. Methods of protecting walls round tents, huts, etc., are shown on Figs. 69, 70 and 71.

Shelter Trenches.

6. The most practicable form of shelter that can be adopted for camps is a trench dug in the ground, about 6 ft. deep and 3 ft. wide, covered by corrugated iron and from 6 ins. to 10 ins. of rammed earth, sand or preferably beaten sand bags. Such trenches should be laid out zig-zag with "returns," no length of straight trench being much more than 20 ft. Besides the entrances at each end there should be intermediate entrances, the number depending on the total length of the trench. These and the entrances should not lead directly into the trench, but be at right angles to the line of the trench.

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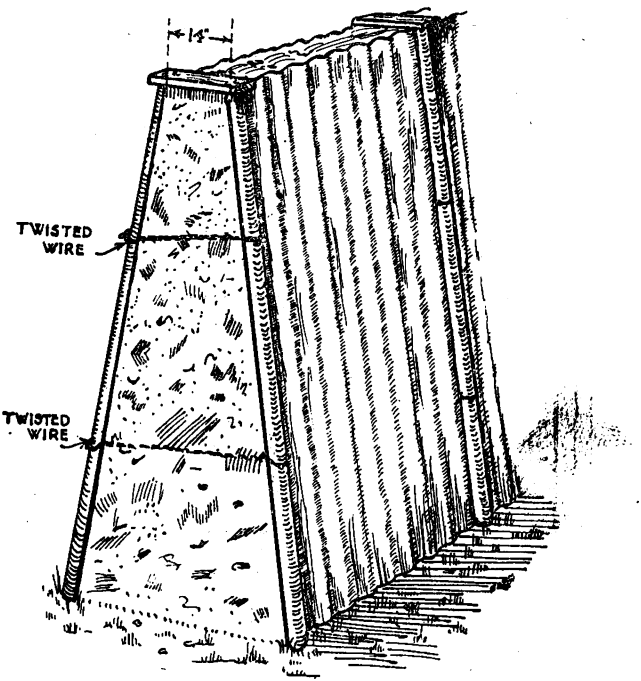

FIG. 67.

Note.—It is not advisable to put on a heavier covering than that referred to above, as if the roof is brought down by the explosion of a bomb near by, the occupants would be exposed to the danger of being suffocated.

Ammunition and Bomb Shelters.

7. Any available shelter may be used, but not more than 100 small shells or bombs or 50 larger projectiles should be stored together in one shelter, and large quantities should be divided up by traverses at least 4 ft. thick. Cartridges other than those of fixed ammunition should be separate from the shells or bombs. Types of ammunition and bomb shelters are :—

For dry ground, *see* figs. 72 and 72(*a*).
For wet ground, *see* figs. 73 and 73(*a*).

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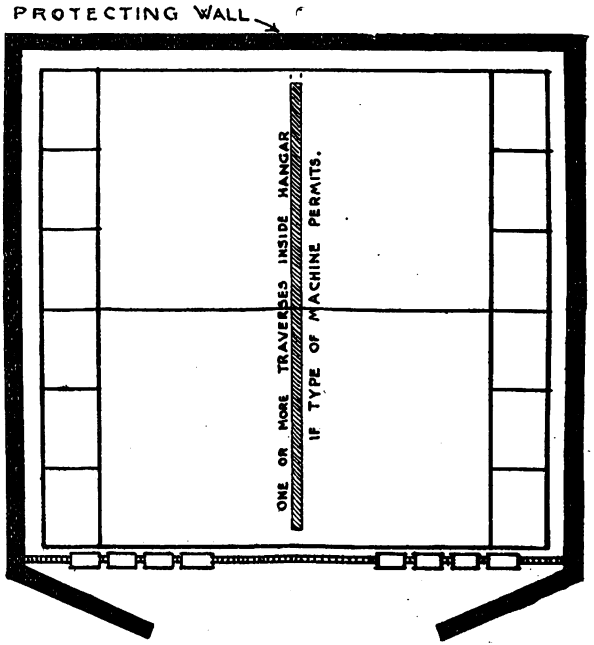

FIG. 68.

20. EMPLACEMENTS FOR ANTI-AIRCRAFT AND MACHINE GUNS.

Anti-Aircraft Emplacements.

1. No special emplacements are usually required for anti-aircraft guns. These are generally situated at some distance from the front lines and are not exposed to much danger from enemy artillery. They are particularly exposed to attack by enemy aircraft and should be protected by camouflage and by avoidance of beaten tracks to the position. For the personnel, shelters or dug-outs should be provided.

2. Fig. 74 shows a type of emplacement for 90 c.m. or 120 c.m. anti-aircraft search light, suitable for skew gear pipe control with telescope.

Machine Gun Emplacements.

3. These often depend for their security on concealment. An open emplacement should be constructed to the dimensions shown on Fig. 75. The platform should be cut well into the bank or parapet, so that when covered the work will not appear to break the continuity of the bank. A box or slip loop-hole will be required for the gun to fire through.

Minimum dimensions of machine gun emplacements are shown on Fig. 76.

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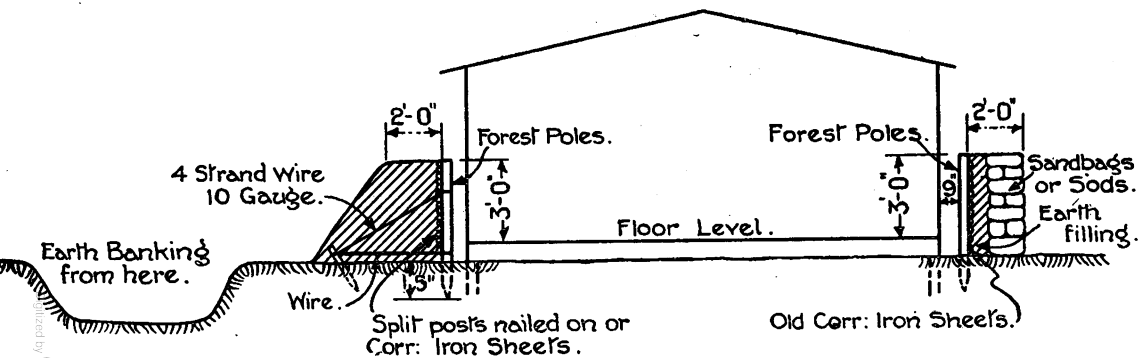

FIG. 69.

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FIG. 70.

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FIG 71

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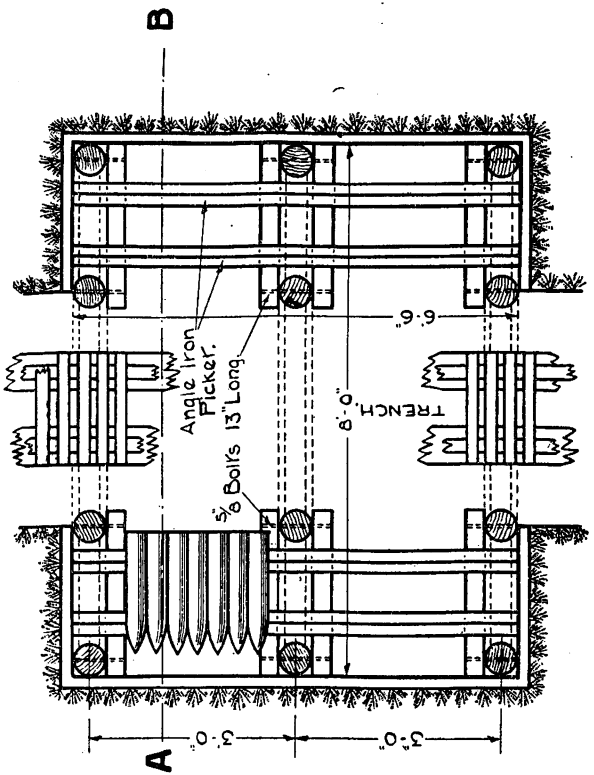

Fig. 72.

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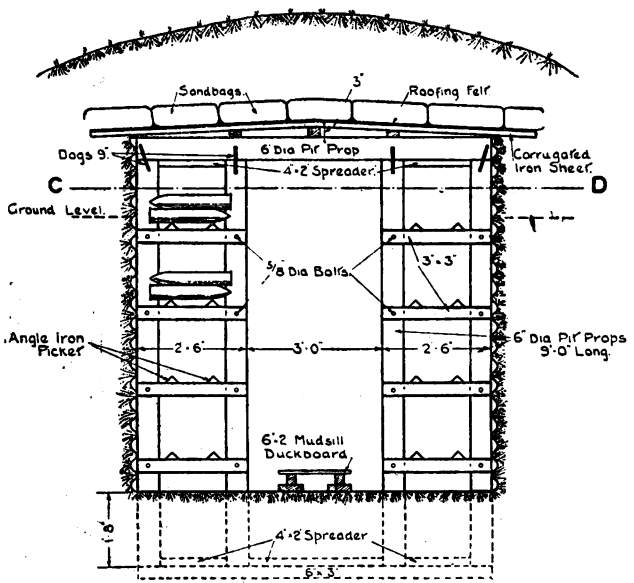

FIG. 72A.

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Fig. 73.

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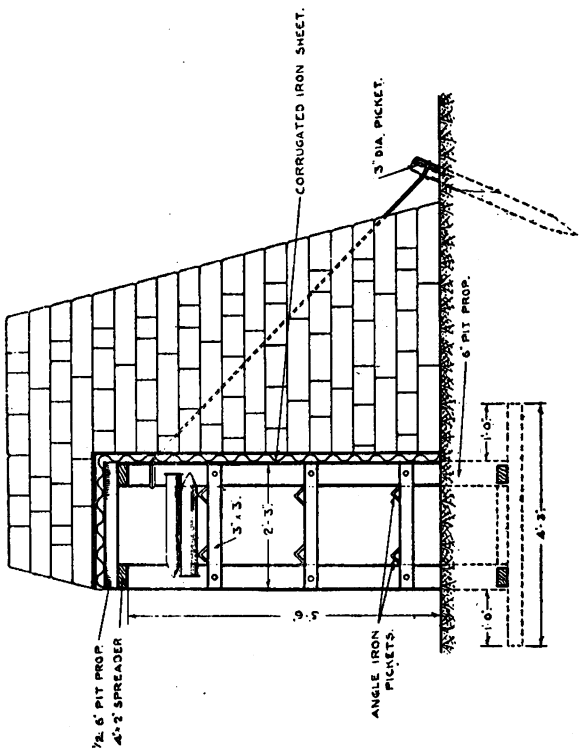

FIG. 73a.

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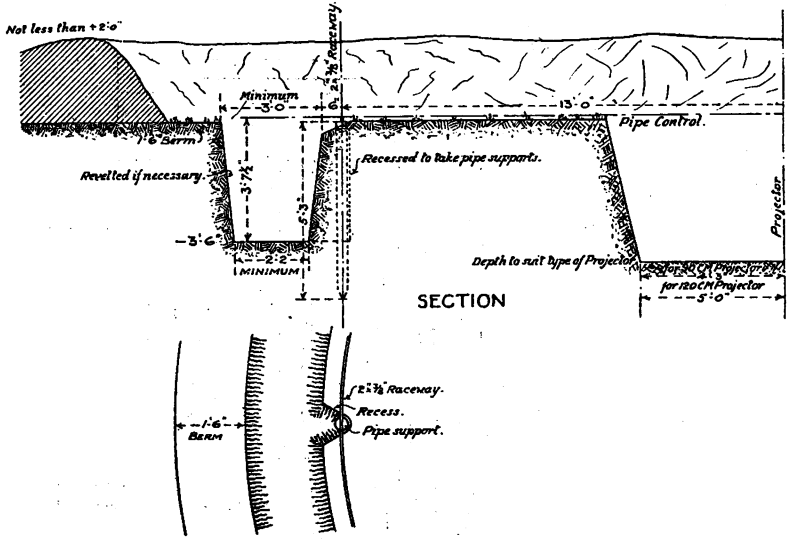

FIG. 74.

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FIG. 75.

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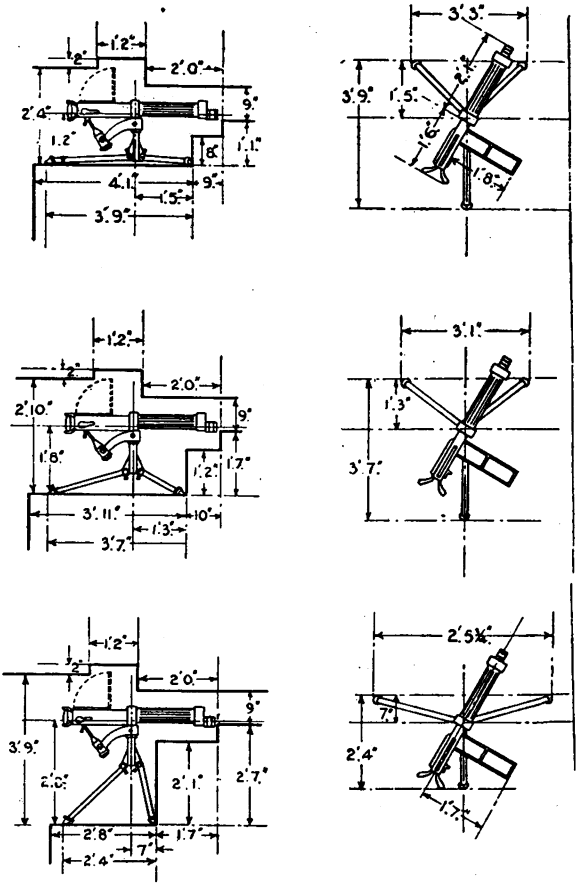

FIG. 76.

4. When under direct observation, splinter proof protection should not be provided, as it may disclose the emplacement and render it difficult to remove casualties. Camouflage from overhead observation may be easily improvised.

21. FIELD BRIDGES.

General.

1. Tactical requirements will determine the locality for a military bridge, but the nature of the banks and approaches, the nature of the

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bed, width to be bridged, depth of water, strength of current, and the probability and extent of floods are important from a technical point of view. If a tidal river, the rise and fall of the tide should be ascertained.

2. The approaches at both ends of a Bridge are a matter of great importance. Easy access and a difficult exit are liable to cause crowding at the entrance to, and on, a bridge, which may lead to accidents and delay.

Bridging Expedients.

3. For tactical reasons, it is often important to pass men, horses and artillery, across water at the earliest possible moment, and some expedient must precede work of a more deliberate nature.

A few of these bridging expedients are given below :—

(*a*) In shallow water, carts or wagons may be used to form the substructure for a bridge.

(*b*) Small gaps may be filled up with bundles of brushwood, channels being left for the passage of the water.

(*c*) Rafts or even piers for bridges may be made of waterproof materials, such as tarpaulins, ground-sheets, etc., stuffed with hay, straw, heather, ferns, etc.

A raft consisting of four 18 ft. × 15 ft. tarpaulins stuffed with hay will carry a load not exceeding 24 cwts. The best method of filling each tarpaulin is to make a light framework of poles 6 feet square by 2 feet 6 inches high, on the ground (a hole of similar dimensions will do almost as well). Then place two lashings about 24 feet long across the framework each way, and over these the tarpaulin, well soaked. Fill the tarpaulin with hay and trample it well down. The ends and sides of the tarpaulin are then folded over the hay, and the whole made into a compact bundle by securing the lashing across the top. (*See* Fig. 77.)

TARPAULIN RAFT.

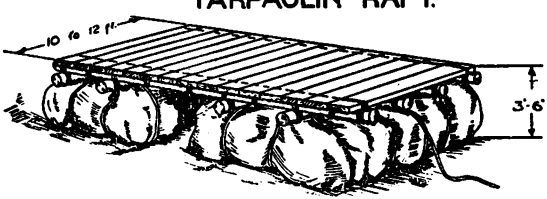

FIG. 77.

The stores required are :—

Tarpaulins	4
Hay, &c. (tons)	1½
Planks	16
Spars (average 4 ins. diam.), four 16 ft., four 14 ft. and two 12 ft.	10
Lashings, 1 in., about 3 fms. long	40
Lashings, 1½ ins., about 6 fms. long	16
Ropes, 2 in., length according to width of river	2
Punting poles	2

Smaller rafts can similarly be made by stuffing ground-sheets with hay or straw; 24 of these made into a raft will support a load of 1,800 lbs. It is essential for the sake of stability that, unless the buoyancy is much in excess of that actually required, the length of each pier of a raft should be twice the width of the platform of the raft. If the raft is formed of one pier only, the part of the platform loaded should only be the central quarter.

(*d*) A rough boat can be made by covering the body of the Mark IX. G.S. wagon with its tarpaulin cover. Any projecting points of the

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wagon must be covered with hay to protect the tarpaulin, and any holes in the wagon should be filled in the same way. The tarpaulin must be kept close to the wagon body by lashings. If sufficient lashings are available, one should be tied right round the wagon two-thirds of the way back from the front, while a second should be lashed round the wagon half way up its side, passing through the eyelet holes in the cover. Four to six men may be carried sitting down in this boat.

Rough boats may be made in a similar way by fastening tarpaulins over a brushwood framework.

Bridges.

4. Where better facilities for the crossing of water or ravines are required some form of bridge will be needed.

The type of bridge will vary according to the materials available, the traffic expected, and the nature, breadth, depth, etc., of the span to be bridged; but whatever arm of the service a bridge is constructed to carry, it should be capable of carrying that arm when its members are crowded.

The most usual forms of bridges are trestle, cantilever and floating. Other methods sometimes employed are suspension, frame and crib work.

5. A bridge that will carry infantry in fours crowded will carry field guns and 4·5-inch howitzers and most of the ordinary wagons that accompany an army in the field.

To prevent it being improperly used, a signboard should be placed at each end, stating the greatest permissible load, thus :—

"Bridge to carry men in fours."
"Bridge to carry men in file."
"Bridge to carry 3-ton heavy tenders unloaded."
"Not for animals," etc.

6. The usual form of roadway is shown at Fig. 78. The normal width of roadway is 9 feet between the ribands; 8 feet will suffice for men in fours or cavalry in half sections; 6 feet for men in file, cavalry in single file and field guns passed over by hand; 1½ to 3 feet for men in single file. Types of trestles and bridges are shown at Figs. 79 to 85 (*c*). Planks 1½ to 2 inches thick are sufficient for ordinary traffic. Handrails 3 feet above the roadway should be provided.

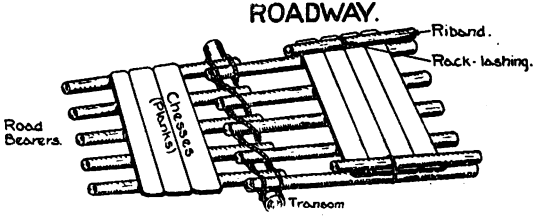

FIG. 78.

Weights of Troops, Guns and Materials.

7. The maximum weights brought on a bridge by the passage of troops in marching order are :—

Infantry, in file, crowded at a check, 2½ cwts. Infantry, in fours, crowded at a check, 5 cwts.	Per lineal foot of the bridge irrespective of width of roadway, if the formation is provided.

Armed men in a disorganised mass may weigh 1½ cwts. per square foot of standing room.

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LASHED SPAR TRESTLE.

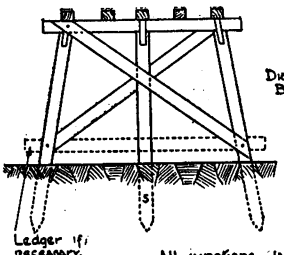


FIG. 79.

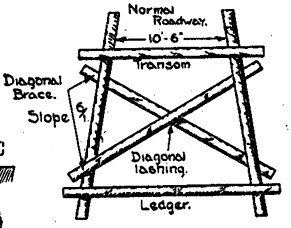
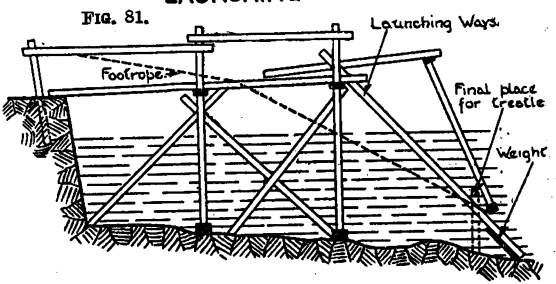


FIG. 80.

All junctions lashed with wire or rope, square lashings except where stated.

LAUNCHING TRESTLES.

FIG. 81.



CANTILEVER BRIDGE.

FIG. 82.

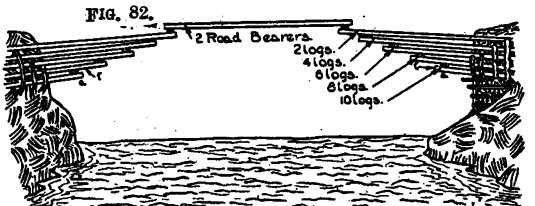


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FIG. 83. CRIB PIER IN SHALLOW WATER

FIG. 84. FLYING BRIDGE

SECTION OF A GAP.

Fig. 85C.

SHORE END.

Fig. 85B.

PARTS OF A BRIDGE.

Fig. 85A.

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8. The maximum weights of R.A.F. vehicles unloaded are given in Chapter VI., Section 38.

9. The weights brought on a bridge by certain animals are :—

	Cwts.
Camels, loaded	15
Camels, loaded, weight on one leg	10
Pack-bullocks	$5\frac{1}{5}$
Pack-bullocks, weight on one leg	$3\frac{1}{2}$
Elephants, loaded, weight on one leg	44

10. The weight of earth 1 in. thick may be taken as 10 lbs. per square foot covered; and of soft timber 40 lbs. per cubic foot.

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Chapter IV.

AEROPLANES.

22. CARE AND MAINTENANCE.

Cleanliness :

1. The fabric of the aeroplane must be kept clean and free from oil, in order to avoid deterioration. To remove dirt and oil from the fabric, rub it well with a piece of waste or rag soaked in warm soapy water. Having removed all dirt and oil, wipe the fabric with a piece of dry cloth.

If warm water and soap is ineffective, petrol may be used, but only very sparingly. Mud thrown on to the fabric by the wheels of the undercarriage should not be allowed to dry, but should be removed as soon as possible. If, however, it has become dry, it should be taken off with warm water and not scraped off as the fabric is liable to be damaged by scraping.

Control Wires :

2. After every flight pass your hand over the control wires and carefully examine them near pulleys. Even if only one strand is broken the wire must be changed. The aileron balance wire on the top plane must not be forgotten. Once a day try the tension of the control wires by smartly moving the control levers about.

Wires :

3. See that all wires are kept well greased or oiled, and that they are adjusted to the correct tension. When examining the wires, make sure that the aeroplane is on level ground, as otherwise it may get twisted, throwing some wires into undue tension and slackening others. The best way, if you have time, is to pack the machine up into its "rigging position."

A slack wire does not always require to be tensioned; perhaps its opposition wire is too tight; in which case slacken it, and possibly it will be found that this will tighten the slack wire.

Carefully examine all wires and their connections near the airscrew, and make certain that they are snaked round with safety wire, so that the latter may keep them out of the way of the airscrew if they come adrift.

Distortion :

4. Carefully examine all surfaces, including the controlling surfaces, to see whether any distortion has occurred. If distortion cannot be corrected by adjustment of wires, the matter must be reported.

Adjustment :

5. Verify the angle of incidence, the dihedral angle, the stagger, and the rigging generally as often as possible.

Undercarriage :

6. Constantly examine the alignment and fittings of the undercarriage, and the condition of tyres, shock absorbers and the tail skid.

Special care should be exercised when examining the "Oleo" type undercarriage.

Control Surfaces :

7. As often as possible verify the rigging position of the ailerons and elevator.

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Locking Arrangements :

8. Constantly inspect the locking arrangements of all turnbuckles, bolts, etc.

Outside Position :

9. The aeroplane, when outside its shed, must always stand *facing the wind*. If this is not so, the wind may catch the controlling surfaces and move them sharply enough to damage them. If the aircraft must be moved during windy weather, the control lever and rudder bar should be lashed fast.

If it is necessary to leave an aeroplane in the open for any length of time, cover engine, cockpit and airscrew blades, to protect from weather.

Handling of Aircraft :

10. When pulling aircraft along the ground, always, if possible, pull from the undercarriage. If necessary to pull from elsewhere, then do so by grasping the interplane struts as low down as possible.

As regards handling parts of an aeroplane, never lay anything covered with fabric on a concrete floor, as any slight movement will cause the fabric to scrape over the concrete with resultant damage. Struts, spars, etc., should never be left about the floor, as in such a position they are likely to become damaged. Remember that wood easily becomes distorted, and this particularly applies to the interplane struts. The best method is to stand them up in as near a vertical position as possible, and shield from the sun.

Care of Airscrews :

11. The care of airscrews is of the greatest importance, as they are very likely to become distorted and lose their correct pitch angle and straightness. Extremes of temperature and humidity should be avoided, and, where airscrews are stored out of cases, they should not be in direct sunlight.

The following are alternative methods of storing. Storage in cases should be adopted where practicable.

(*a*) Airscrews stored in their cases should be stacked horizontally. Large cases containing airscrews should not be stacked on top of one another, but each stack should consist of cases of similar type.

(*b*) Where cases are not available, airscrews should be placed on a vertical or horizontal spindle. If stored on a vertical spindle, the leading edges should be downwards. If stored on a horizontal spindle, the position of the two-bladed airscrew should be horizontal.

Airscrews stored in this manner should be turned from time to time, and left with a different blade uppermost, to prevent moisture or sap getting down and disturbing the balance.

Airscrews out of their cases are not on any account to be rested on their blades.

Mounting Airscrews :

12. Be careful to see that the airscrew is mounted quite straight on its shaft. Bring the tip of one blade round to graze some fixed object. Mark the point it grazes. Now bring the tip of the other blade round to the mark, and it should be within $\frac{1}{4}$ in. of it. If it is not within $\frac{1}{4}$ in. of the mark, it is due either to the propeller being faulty, in which case it should not be used, or to some of the airscrew bolts being too slack or to others being pulled up too tight.

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AEROPLANES.

23. Rigging Details and Dimensions.

—	Avro(*a*) 504K.	Bristol Fighter F.2B.	D.H. 9A.	D.H. 10.	Fairey III.D.	F.5.	Parnall Panther N.2A.	Sopwith Snipe 7.F1.	Vickers Vernon.	Vickers Vimy.	Westland Walrus.
Upper Main Planes:											
Span	36′ 0″	39′ 3″	45′ 10½″	65′ 5″	46′ 1½″	103′ 8″	29′ 6″	30′ 0″	68′ 0″	67′ 0″	45′ 10½″
Chord	4′ 9½″	5′ 6″	5′ 9″	7′ 0″	5′ 6″	8′ 0″	6′ 3″	5′ 0″	10′ 6″	10′ 6″	5′ 9″
Incidence	4°*	1° 42′	3°	7°	4½°	4°	2°	1° 50′	3½°	3½°	3°
Dihedral	2½°	3½°	3°	4½°	1° 40′	1½°	2°	4°	3°	3°	3°
Lower Main Planes:											
Span	36′ 0″	39′ 3″	45′ 10½″	65′ 5″	46′ 1½″	74′ 2½″	29′ 6″	30′ 0″	68′ 0″	67′ 2″	45′ 10½″
Chord	4′ 9½″	5′ 6″	5′ 9″	7′ 0″	5′ 6″	8′ 0″	6′ 3″	5′ 0″	10′ 6″	10′ 6″	5′ 9″
Incidence	4°	1° 42′	3°	7°	4½°	4°	2°	1° 50′	3½°	3½°	3°
Dihedral	2½°	3½°	3°	4½°	1° 40′	1½°	2°	4°	3°	3°	3°
Gap	5′ 6″	5′ 4½″	5′ 10½″	7′ 0″	5′ 7″	8′ 8″	6′ 2″	4′ 3″	10′ 0″	10′ 0″	6′ 0 1/16″
Stagger	24″	18·1″	16″	Nil	Nil	Nil	19″	16″	Nil	Nil	Nil
Length, overall	28′ 11″	25′ 9″	30′ 0″	39′ 8″	36′ 0½″ (over sling)	49′ 3½″	25′ 0″*(*d*)	20′ 0″	43′ 8″	44′ 2″	31′ 6″
Height	10′ 5″	9′ 7½″	11′ 6″	15′ 0″(*b*)	13′ 1″	18′ 9″	10′ 6″	9′ 6″	15′ 0″	15′ 3″	11′ 9″
Incidence of Tail Plane (Centre Line).	Bottom bolt in 3rd hole from bottom.	−3° 20′ to − 20′	Bobbin in middle of screwed sleeve.	Bobbin in middle of screwed sleeve.	+1° to + 5½°	2½°	1°	3°	Pin in 3rd hole from bottom.	3rd hole from top.	0°
Normal position of Control Column.	Vertical	Vertical	6° Forward	Vertical	2° Forward	10° Forward	10° Back'd	Vertical	Vertical	Vertical	Vertical
Droop of Ailerons	Nil	¾″	1″	1″	¾″ (*c*)	¾″	¾″	¾″	1½″	1½″	¾″
Droop of Elevator.†	Nil	Horizontal.	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

* 30′ wash in on port planes. † With Control Column in normal position. (*a*) For 100 H.P. Mono. type.
(*b*) At wing tips—Height at centre section 13′ 0″ (approx.). (*c*) With tail plane set at angle of incidence of 2½°.
(*d*) Overall length with tail folded 14′ 6″.

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24. Rigging Faults and their Correction.

(*Note.*—This table is intended as a guide to assist in discovering the causes of certain faults. In all cases the designers' rigging instructions should be rigidly observed.)

Symptom.	Cause.	Remedy.
Directional stability bad (*i.e.*, machine does not fly straight).	(*a*) Angle of incidence of main planes, or tail plane wrong, alignment of fin wrong.	(*a*) Measure and correct.
	(*b*) Alignment of fuselage wrong.	(*b*) do.
	(*c*) Dihedral wrong.	(*c*) do.
	(*d*) Struts or streamline wires not true in line of flight.	(*d*) do.
	(*e*) Surfaces distorted.	(*e*) Measure camber and inspect leading and trailing edges of planes.
Lateral stability bad (*i.e.*, machine flies one wing down).	(*a*) Angle of incidence wrong on one or both sides.	(*a*) Measure and correct.
	(*b*) Surfaces distorted.	(*b*) Measure camber and inspect leading and trailing edges of planes.
Longitudinal stability bad (*i.e.*, machine nose or tail heavy).	(*a*) Stagger may be wrong.	(*a*) Measure and correct. See that fittings have not pulled into wood.
	(*b*) Angle of incidence of main planes wrong.	(*b*) Measure and correct.
	(*c*) Angle of incidence of tail plane wrong.	(*c*) Check fuselage for truth; tailplane may be correct relative to rear of fuselage, and wrong compared with datum line.
	(*d*) do.	(*d*) Measure and correct. *Note.*—Be careful not to give the tail plane an angle of incidence greater than specified, as this may render the aeroplane uncontrollable longitudinally.

25. Rigging—General Notes.

1. Rigging must be carried out carefully and methodically. The notes given below are arranged in the order in which operations are carried out, and apply generally to all aeroplanes.

Special points to be observed are given in details under the name of each aeroplane.

Rigging Position :

2. Trestles must be placed at correct positions under fuselage. Level transversely by packing blocks under trestles. Level longitudinally by raising or lowering tail.

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Fuselage :

3. All aeroplanes are symmetrical in plan view. If an aeroplane is not symmetrical in elevation, points which are to be lined up are given in details.

Select two suitable bays at front and rear respectively, and true up vertical cross bracing wires of these bays until diagonals are equal.

Clamp straightedge across each of these bays, the top being exactly level with the centre of the side struts (or the point given in details) on either side. Mark mid position between side struts, and stretch cord between to axis of sternpost. Mark also two points on straightedge just outside fuselage, and stretch cord between.

Working from front to rear :—

(*a*) Adjust internal cross bracing wires until corresponding diagonals are equal in each section.

(*b*) Adjust top and bottom cross bracing wires until all mid points on top and bottom transverse struts and internal cord are in the same vertical plane. Check by plumb line, which should *just touch* internal cord.

(*c*) Adjust side cross bracing wires on both sides until the centres of struts (or marked points, as case may be), are in line with the outer stretched cords. Check by computers' square or by sighting.

Note :

(*a*) It is important during the whole process of truing up continually to check sternpost, and ensure that it is vertical by plumb line.

(*b*) Do not *overtighten* any bracing wires.

(*c*) See that turnbuckles have threads well engaged and are locked.

(*d*) Burr over bolts on fuselage after truing up, and see that lock nuts are tightened and all split pins in position.

Undercarriage :

4. Undercarriage should be symmetrical about the vertical centre line of the aeroplane, viewed from the front.

Drop plumb line from centre of machine, or from points equidistant on each side, and check.

Axle should be at right angles to longitudinal axis of aeroplane. Check by taking measurements from sternpost to axle end collar of undercarriage wheels. This measurement should correspond on both sides.

Centre Section :

5. Before fitting upper centre section invert it on trestles, and fix and split pin all centre section bracing wires.

Place centre section struts in their sockets on the top longeron, and set centre section in position, connecting up bracing wires.

Centre section should be symmetrical about vertical centre line of aeroplane.

Adjust transversely by cross bracing wires, and check by plumb line and bottom longerons, and by spirit level along front and rear spars.

Adjust longitudinally by side bracing wires, until stagger and incidence are correct. Check stagger by plumb line, measuring horizontal distance from corresponding point on the lower plane. Check incidence by field clinometer or Abney level.

Main Planes :

Main planes should be placed with leading edges on the ground, resting on wood or felt, and all interplane struts fitted. Incidence wires, landing and flying wires in the outer bays are also loosely connected.

Main planes are then lifted into position by struts, and roots of spars are inserted in position and fixed, and the remaining wires attached.

Adjust the front landing wires until the distances XX and YY are respectively equal on port and starboard sides. The distance XX is that between mid point of leading edge of upper centre section and bottom socket on front outer interplane strut. The distance YY is that between a point on the front spar at the root of the lower main plane and the top socket of front outer interplane strut.

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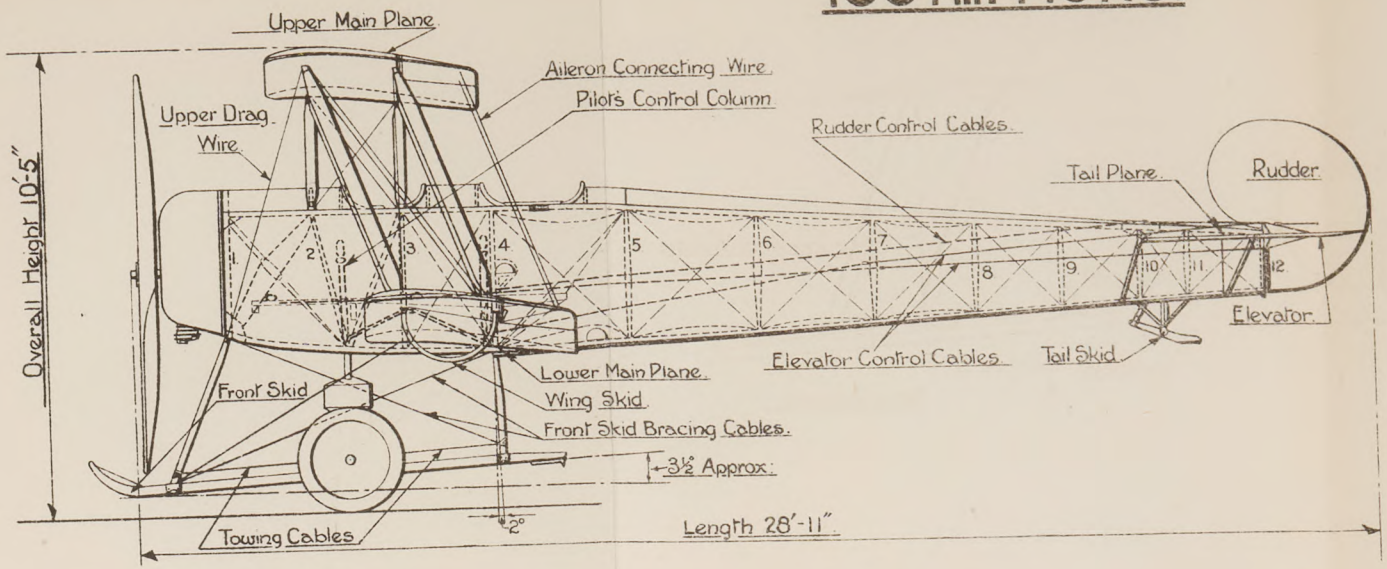
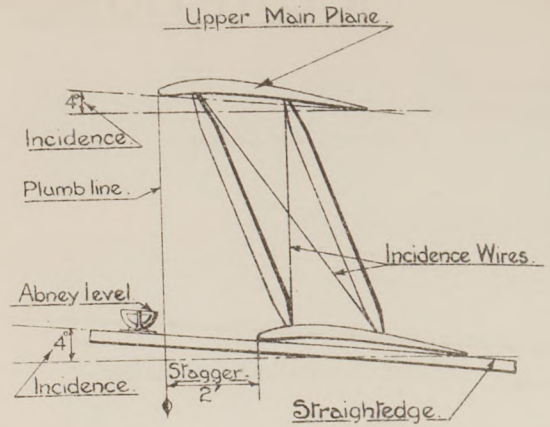
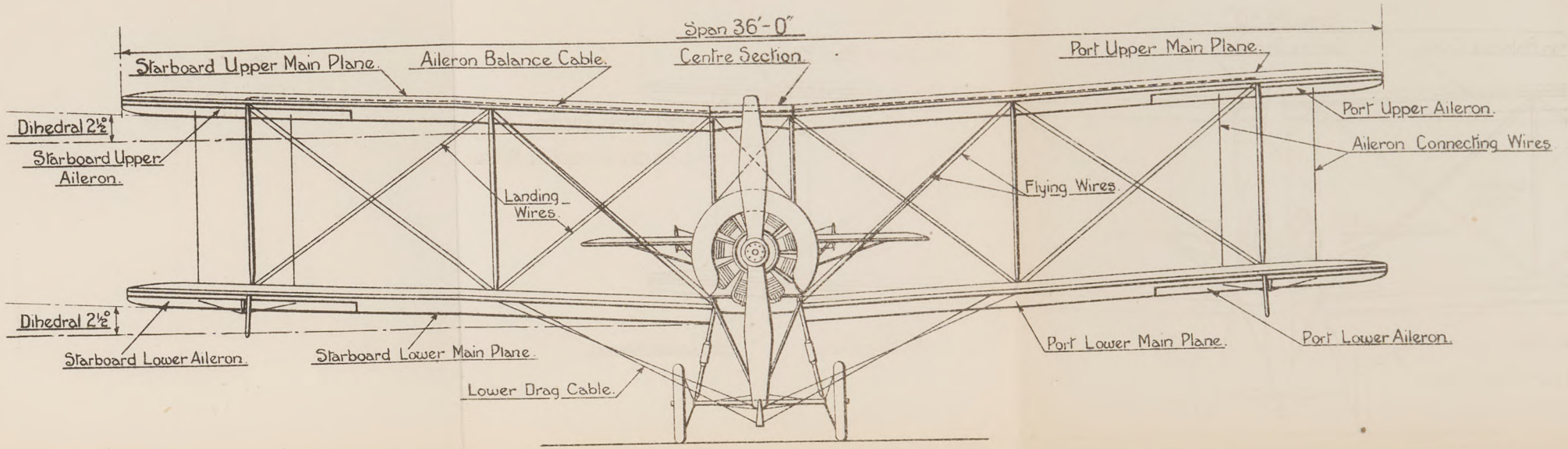
AVRO 504K.
100 H.P. MONO.

FIG. 86.







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Leading edges of upper and lower main planes should be symmetrical in plan about longitudinal centre line of aeroplane. Check by measurements from bottom sockets of front outer struts to sternpost or point equidistant from centre line at rear. These measurements should correspond.

Adjust *dihedral* by means of front landing wires, working outwards, and check by field clinometer or Abney level and straightedge along front spars.

Rear landing wires should be adjusted so that rear spar corresponds.

Adjust *stagger* by incidence wires, and check by plumb line from leading edge of upper main planes in front of each strut. Stagger is measured horizontally.

Adjust *incidence* by incidence wires and rear landing and flying wires, and check by field clinometer or Abney level and straightedge along the chord of a rib.

Note.—On completion of adjustment, dihedral, stagger and incidence should be rechecked, as adjustments for one may affect the others. Do not depend upon tables of "Pin centre lengths" of bracing wires, but see that actual angles, etc., are correct.

Empennage :

7. By means of bracing wires, true up until the tail plane is level transversely. Check by spirit level on front and rear spars. Rear spar should be square with the longitudinal centre line of machine. Check by measurements from bottom rear spar attachments of main planes (or other suitable point), to lateral extremities of tail plane rear spar. Corresponding measurements should be the same on both sides.

Where incidence of tail plane is variable, control should be adjusted to work between limits set down.

Controls :

8. Controls should be set as shown for each aeroplane. During adjustment, control column should be fixed in neutral position, which is vertical unless otherwise specified.

Rudder should be set fore and aft, with rudder bar square across fuselage.

Fins are set fore and aft unless otherwise specified.

Control cables should work freely.

26. Special Rigging Notes.

AVRO BIPLANE 504 K.

(Monosoupape.)

Rigging Notes.

Rigging Position :

1. With undercarriage detached, support the fuselage under the bottom longeron at side-strut 2, and just forward of the sternpost. Adjust the bracing wires until the upper longerons forward of No. 4 side struts both lie in the same horizontal plane. The fuselage should be symmetrical in plan and in side view to the rear of No. 6 side struts. Mark the mid points of all top and bottom cross struts, and of all side struts to the rear of strut 5, for alignment in the usual manner.

Undercarriage :

2. Fit the undercarriage to the lower longerons. Set the fuselage in its rigging position, supporting it to the rear of the undercarriage so that the landing wheels are out of contact with the ground. Adjust the rear struts of the V so that their rear faces shall be inclined backwards 2°, and check with an incidence protractor. To effect the adjustment, manipulate the landing and drift cables. With the V thus set, the main skid will have an incidence of about 3½°.

The slope of the compression struts is determined by the length of the front towing cables. When new, the latter should both be of the same length (most important), which is 3 ft. 9¼ in. from thimble to thimble. This allows for a ¼ in. stretch when the cables are tightened up.

The axle should be at right angles to the main skid. Adjust by means of the rear towing cables, and check by measuring from heel of skid to ends of axle on each side. These dimensions should correspond.

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Centre Section :

3. Fit struts into their sockets in centre section, and mount centre section in place. See that all struts bed right home. When adjusted, both main spars should be horizontal; in side view the front struts should be vertical and the angle of incidence 4°.

The stagger must be 2 ft. To check, drop plumb lines from the gauge points on the base plates of the front strut upper sockets, and adjust the incidence wires until the gauge points are shown to be vertically above the base plates of the lower front strut sockets. With these points in line, the horizontal distance between the plumb lines and the centres of the lower plane front sockets should be 2 ft. Correct stagger must, if necessary, be obtained at the expense of the verticality of the centre section struts by adjustment of the incidence wires.

Main Planes :

4. Assemble in the usual manner. Adjust the incidence to that of the centre section (4°). Check the stagger (24 in.)

Adjust dihedral to 2½° and check by straight edge and clinometer. A second check may be made by stretching a cord over the front spars of the upper planes. This should clear the front spar of the centre section by 8 ins.

Adjust for a wash in on the port main planes of ½ in.

Check the leading edges of both planes for being at right angles to the centre line of fuselage by measuring from outer rear (or front) strut sockets to sternpost on each side.

Empennage :

5. Fit the tail plane leading edges in the sleeve in the fuselage and by means of the adjustable stays adjust the planes; level transversely. Set the centre line of tail plane (as seen from the side) parallel to top longerons, then raise the rear spar ½ in. This will give the correct tail plane incidence. When sternpost is provided with 10 holes, place bottom bolt in tail plane spar clip in 4th hole from bottom for trial flight.

Controls :

6. Adjus tto figures in table.

BRISTOL FIGHTER F.2.B.

(FALCON.)

RIGGING NOTES.

Rigging Position :

1. Support the aeroplane underneath undercarriage struts and near the sternpost tube. Place blocks sufficiently high to clear all obstacles on the gunner's platform, ensuring that blocks are of the same height. Place straightedge across blocks, and level longitudinally by raising or lowering the tail. Level transversely in usual manner.

Fuselage :

2. The fuselage is symmetrical throughout in plan view and from the top of side strut No. 4 to the horizontal sternpost tube in side elevation.

To true up, mark middle points of top and bottom struts, and of side struts 4, 5, 6, 7, 8, 9, and 10, on both sides.

Fit jigs to ensure that the correct distance is maintained between sternpost tube and tail plane kingposts, over which upper and lower fins fit.

Undercarriage :

3. The lower centre section plane must be fitted *before* the undercarriage can be bolted in position.

To true up the undercarriage, adjust the front cross bracing wires until corresponding diagonals are equal.

Centre Section :

4. The upper centre section struts are first bolted to the upper centre section plane, which is then lifted into position, and the *lower ends* of the struts bolted to the centre section strut fittings on the top longerons.

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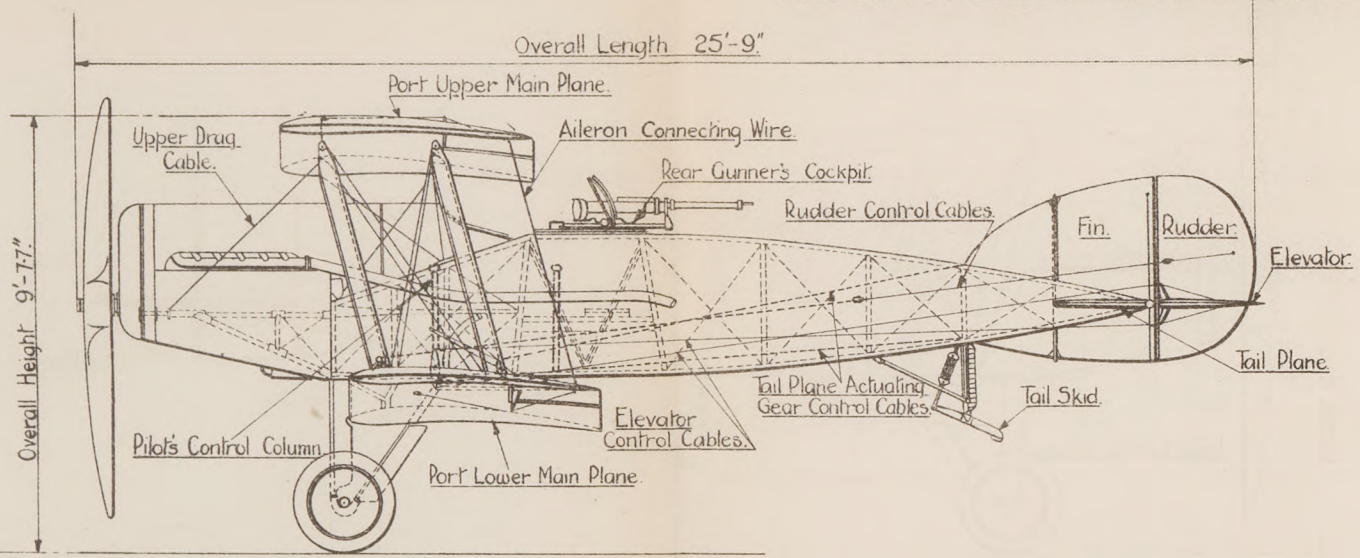
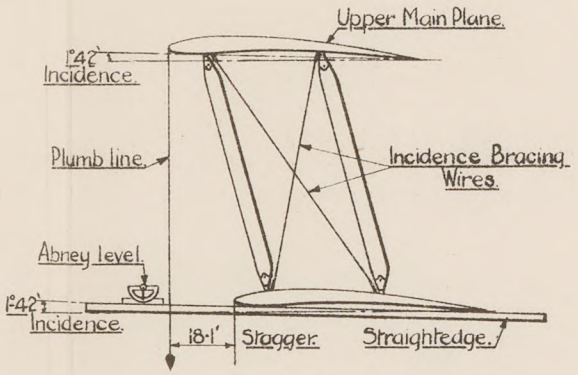
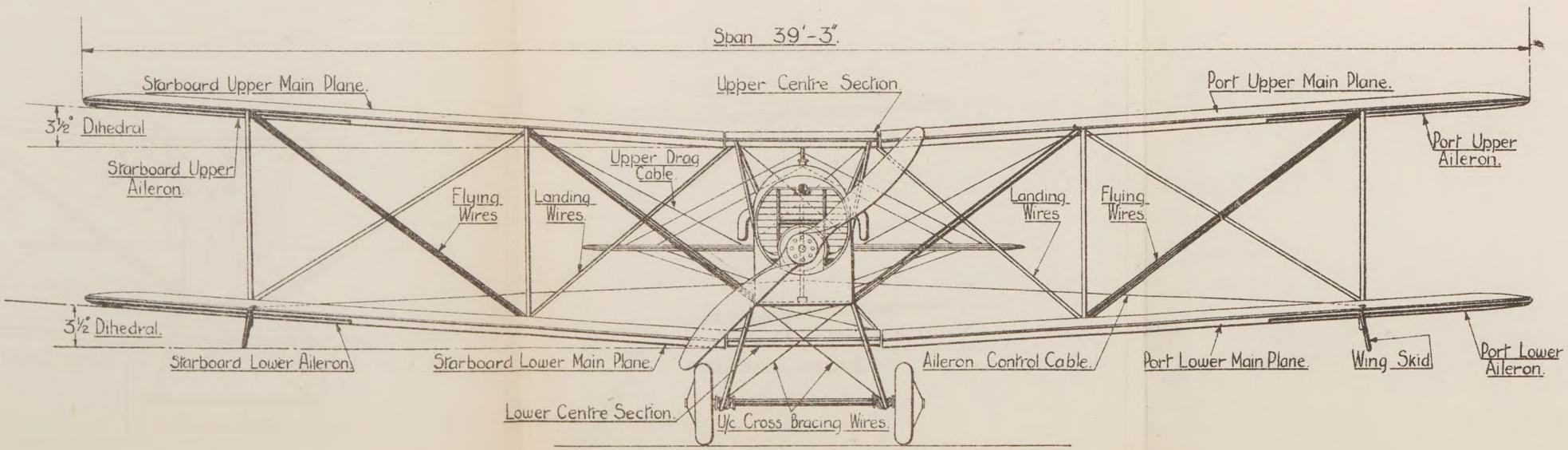
BRISTOL FIGHTER F. 2.B.
ROLLS-ROYCE FALCON III.

FIG. 87.







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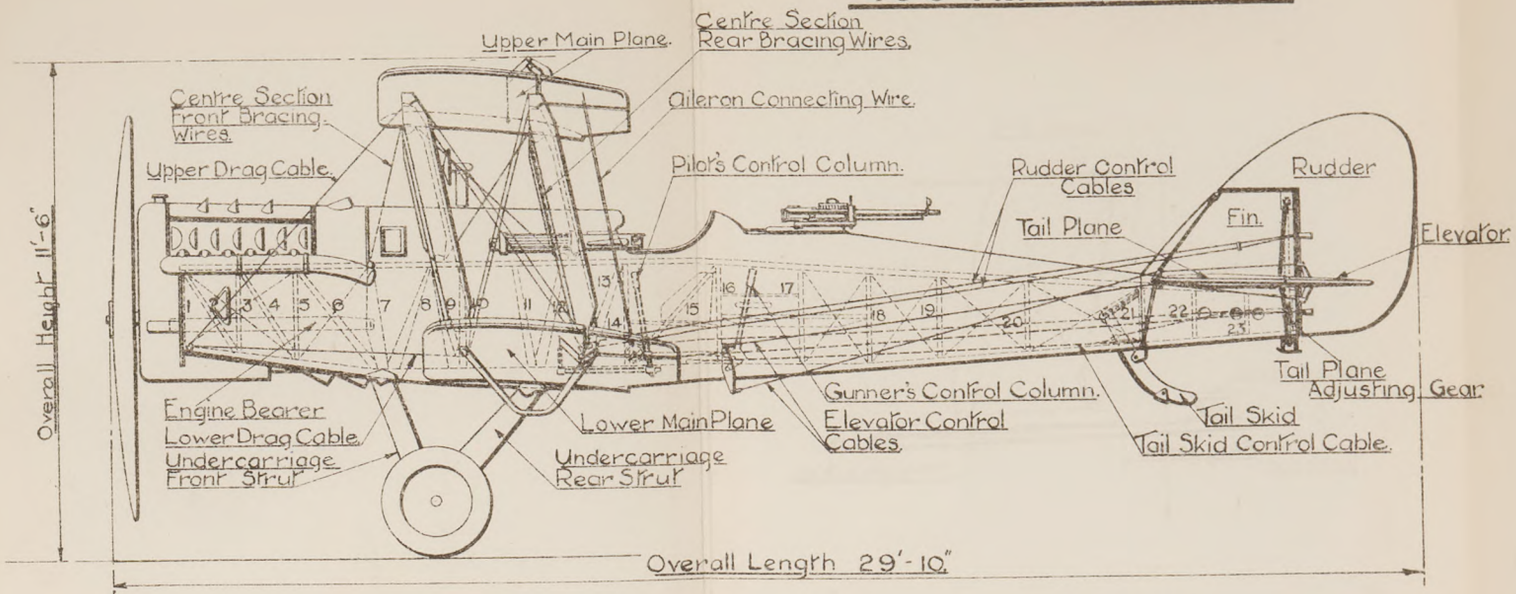
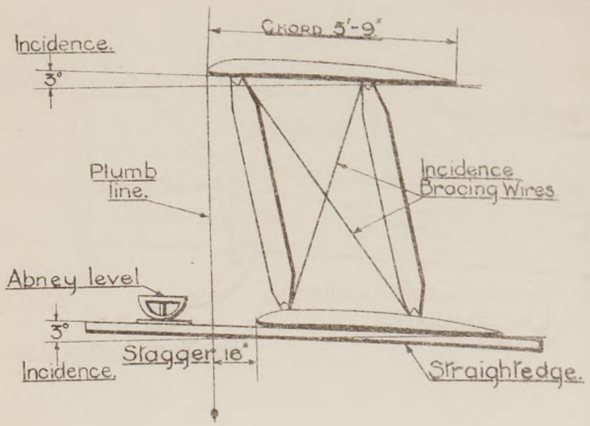
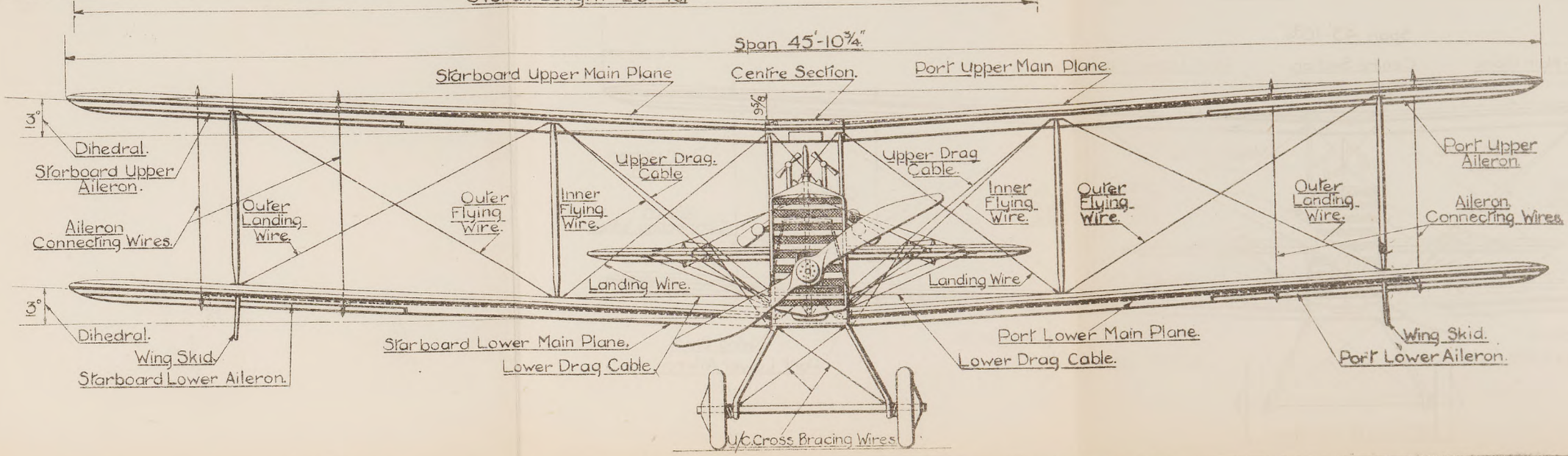
D.H. 9A.
400 H.P. LIBERTY.

FIG. 88.







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Cross bracing wires are then loosely connected.

The main plane landing wires are attached to the lugs on the upper centre section plane.

The lower centre section plane cannot be adjusted in a *fore and aft* direction, and is adjusted transversely by making the front cross bracing wires equal.

Main Planes :

5. To true up main planes, drop plumb lines from the leading edges of the upper main planes at six points, three on each side, and true up to figures given.

Empennage :

6. Fit upper and lower fins in position and secure the lower fin to fixing both on the skidpost, and the upper fin to the bolts on the top cross strut of the fuselage, above the skidpost.

Fit the tail plane in position and loosely connect the bracing wires from fins to tail plane.

True up until the tail plane spars are horizontal and rudder hinges on fins are vertically over one another.

Check the former by spirit level, and the latter by plumb line.

Check for tail being square with fuselage by taking measurements from lateral extremities of rear spars to rear outer interplane strut sockets. These measurements should be the same on both side.

Controls :

7. Adjust to figures in table.

Tail Plane Actuating Gear :

8. The tail plane is adjusted by a large hand lever, working on a quadrant, on the right-hand side of the pilot's seat. This lever raises or lowers the tail plane front spar. When the handle of the lever is *raised*, the leading edge of the tail plane is *depressed*, and *vice versa*.

The total movement of the leading edge of the tail plane should be about 1¼ ins.

When the leading edge of the tail plane is midway between its highest and lowest positions it should be about ¼ in. to ½ in. *below* the centre line of the side of the fuselage. In other words, when the tail plane (and also, therefore, the hand lever), are in their *mean positions*, the tail plane should have a *negative* incidence of about ¼ in. to ½ in.

The actuating cables between the hand lever and the bell cranks should be kept fairly taut.

Care should be taken that the turnbuckle on the bell crank ends are so adjusted that the right and left-hand bell cranks are parallel to one another, top to top and bottom to bottom; otherwise there will be a tendency to cant the tail plane front spar.

DE HAVILLAND 9.A.

(Liberty Type 12.)

Rigging Notes.

Rigging Position :

1. Support aeroplane under side struts Nos. 10 and 21.

The aeroplane is in rigging position when the top faces of the bottom longerons between side struts Nos. 7 and 17 are level longitudinally, and the front and rear spars at the bottom of the fuselage are level transversely.

Fuselage :

2. All the fuselage struts are numbered from front to rear.

Mark points 16¾ ins. vertically below the upper surface of the top longerons on all side struts from Nos. 1 to 14 inclusive, and mark points midway between top surface of upper longerons and bottom surface of lower longerons on all side struts to the rear of side strut No. 15.

Mark the mid points of all top and bottom transverse struts.

Align in usual manner.

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Undercarriage :

3. The undercarriage frame is rigid longitudinally, and does not permit of adjustment. It must be symmetrical about the vertical centre line of the aeroplane when viewed from the front, and the axle must be at right angles to the longitudinal axis of the fuselage.

The shock absorbers on each wheel are formed by two coils of elastic. Each coil consists of 11 ft. of $\frac{5}{8}$ in. diam. elastic, which is given 10 complete turns round the axle, 8 turns being in line, and 2 turns being wrapped over the others.

Centre Section :

4. Before attaching the centre section plane, place it upside down on trestles, and fix the gravity tank securely in position, taking care to see that the rubber washer on the securing bolts and the fibre packing are in place. See that the centre section plane is horizontal, and is symmetrical when viewed from the front.

Adjust longitudinally by the side bracing wires until the stagger is correct. Check by dropping plumb lines on each side from the front edge of the outer bolt holes in the fish plates at the ends of the front spar. The fore and aft horizontal distance between these plumb lines and the corresponding points on the lower spar fittings should be 16 ins.

Main Planes :

5. To check dihedral, a taut cord stretched across the upper main planes between points over the front outer struts should be $9\frac{3}{4}$ ins. above the front spar of the centre section upper plane. Check by dihedral board (or Abney level and straightedge), placed along front spar.

There is no wash-in or wash-out.

Empennage :

6. The incidence of the tail plane is adjusted from the pilot's cockpit by means of a screwed sleeve fixed on a vertical adjusting tube, the latter being fixed in the fuselage just forward of the sternpost, and attached to the tail plane rear spar. A screwed bronze bobbin, which is fixed in a bracket bolted to the sternpost, works on this sleeve, and is rotated by means of two 5 cwt. cables which are sweated to the flanges of the bobbin, and connected to a wheel in the pilot's cockpit. As the bobbin revolves, the adjusting tube is raised or lowered according to the direction in which the wheel is turned, and so moves the rear spar, the tail plane being hinged about the front spar, which is connected by two eyebolts to top transverse strut No. 21. For trial flight the bobbin should be in the middle of the screwed sleeve, the thread of the sleeeve being sufficient to allow 1 in. travel, either up or down.

The shock absorber on the tail skid is formed of $6\frac{1}{2}$ ft. of $\frac{1}{2}$ in. diameter elastic, which is given four complete turns (*i.e.*, eight strands in a section taken through the middle), and secured by balloon cord wrapped in two places. The two limit wires are $13\frac{1}{2}$ ins. in length, measured from the outside of the bobbin on the skidpost to the inner face of the skid. A copper tube, by means of which the skid can be lubricated, is brought up above the fairing, just forward of top transverse strut No. 21.

The fin should be vertical and point fore and aft.

Controls :

7. Adjust the controls with the pilot's control column inclined *forwards* at an angle of 6° with the vertical, and gunner's control stick inclined *backwards* at an angle of $13\frac{1}{2}$° with the vertical. The droop of the ailerons is 1 in. with the pilot's control column vertical.

FAIREY SEAPLANE III D.

EAGLE VIII.

RIGGING NOTES.

Rigging Position :

1. The aeroplane is in rigging position when top longerons between side struts No. 3 and sternpost are level longitudinally and transversely. Support under struts Nos. 2 and 12.

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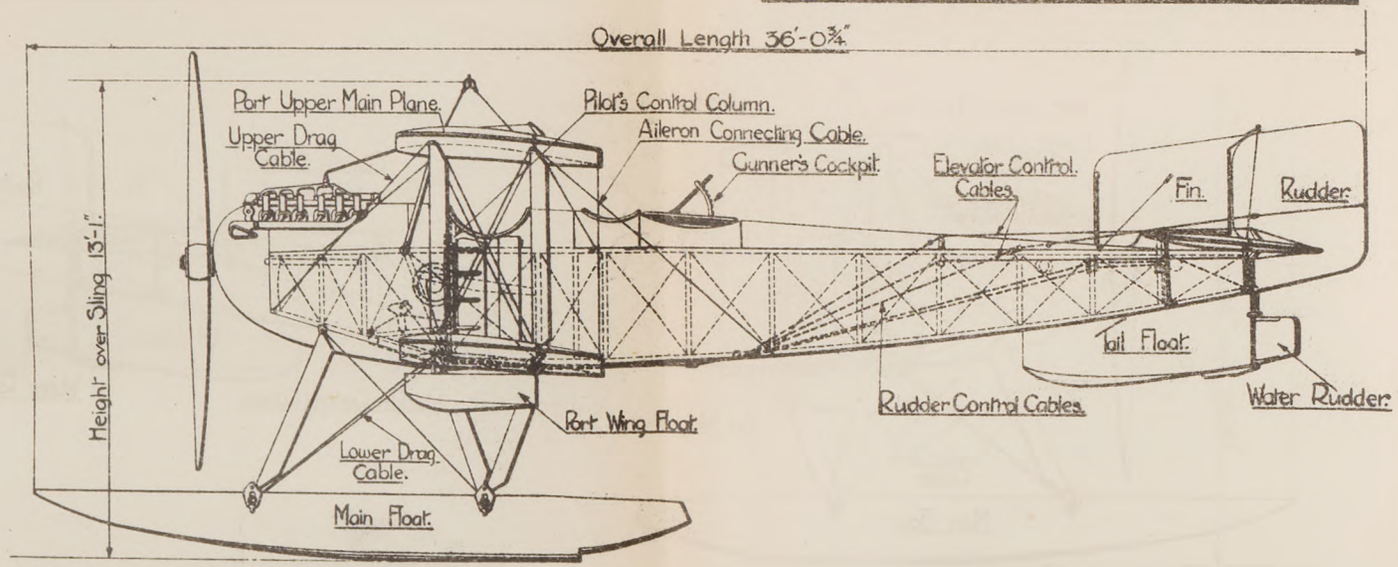
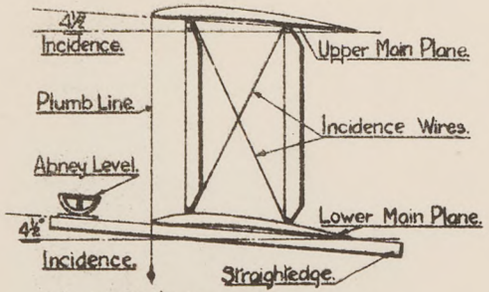
FAIREY SEAPLANE (TYPE IIID).
ROLLS-ROYCE EAGLE VIII.

FIG. 89.

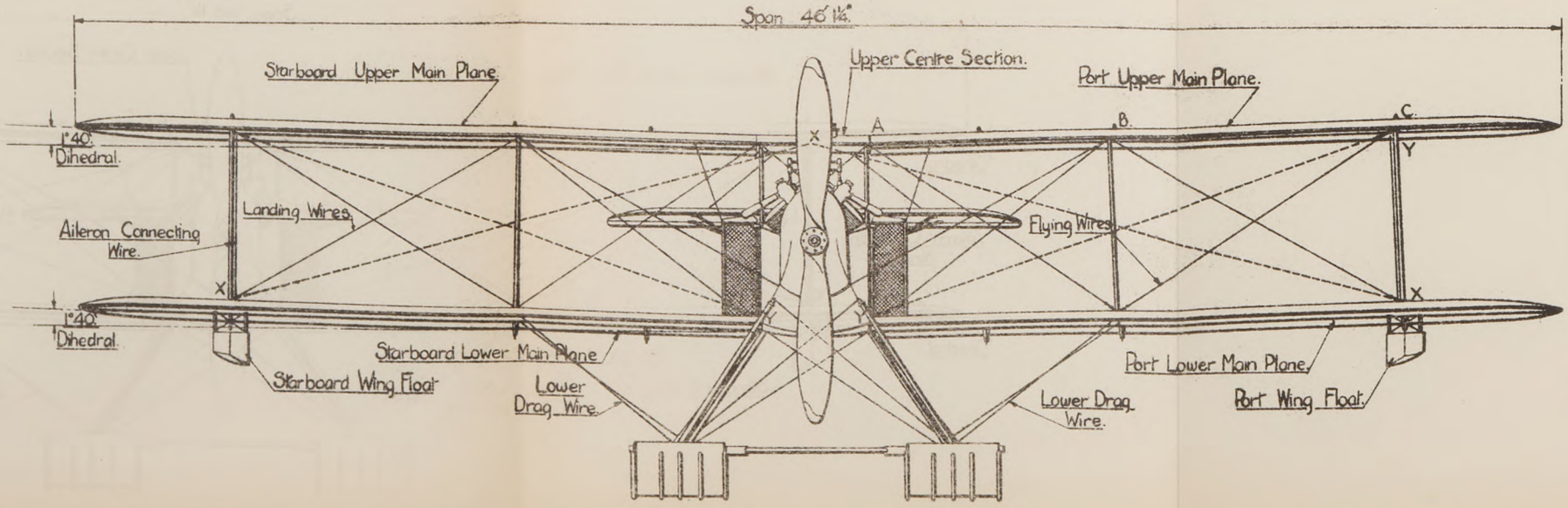




Angles of Incidence.

Incidence @ A.	4°30'.
" " B.	4°22'.
" " C.	4°15'.

These angles occur on Port side for Left-hand Tractor and on Starboard side for Right-hand Tractor: The opposite remains 4°30' constant making a total washout of 15'.



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Fuselage :

2. The side struts are numbered from front to rear.

Lightly clamp straightedges along the top longerons so that they project 4 ft. forward of side struts No. 4. Mark points from the under edge of straightedges 5½ ins. down on side struts Nos. 1, 2 and 3 respectively. These points correspond with the centre line of engine bearer tubes. On all remaining side struts, mark points 5½ ins. down from the top of top longeron. These marked points will all be in a horizontal plane when the fuselage is trued up.

Mark the middle points of all top and bottom transverse struts.

Adjust in usual manner.

Centre Section :

3. Assemble and adjust in usual manner.

Chassis :

4. Place the floats complete with the two cross booms and fittings in position under the fuselage. Insert the struts in position, bolt up the ends to the lugs on the fuselage and booms, and loosely connect all bracing wires. The trestles should now be taken from under the front part of the fuselage and the weight of the aeroplane allowed to rest on the chassis, a trestle being left under the tail float to support the after portion of the machine.

The two cross booms should be level both transversely and longitudinally. Adjust by placing the packing blocks under the floats, and check.

The chassis should be symmetrical about the vertical centre line of the machine when viewed from the front.

Shock absorbers, consisting of 36 ft. of ⅝ in. diameter elastic wrapped seven times in one layer, are provided in two places at each end of the front cross boom.

In a similar manner, shock absorbers are provided in four places on the rear cross boom; at each place there are 17 ft. of ⅝ in. diameter elastic, doubled and wrapped fifteen times.

Thus a total length of 104 ft. of ⅝ in. diameter elastic is required for the float booms, 9 ft. at each of 4 fittings of front boom, and 17 ft. at each of 4 fittings of rear boom.

Each wing float is attached by means of three vertical oval steel tubular struts connected by bracing wires. Slight adjustments may be made transversely by the front cross bracing wires, and longitudinally by the side bracing wires. The struts should be perpendicular to the spars.

Main Planes :

5. The main planes are hinged at the root of the rear spars. Fit the male hinge piece at each end of the rear spar tube into the forked hinge pieces at the ends of the rear spar of the main planes, and insert the hinge pin eyebolts, securing them with castle nuts and split pins. The fork and eye attachments by which the roots of the front spars are connected to the front spar tube under the fuselage, are secured by locking pins, which are inserted just above the leading edge, and are kept in position by a ⅜ in. diameter screw thread.

The locking pin should be screwed right home with a tommy bar attached to it.

Adjust in usual manner.

No measurement should be made from any point on the engine or propeller shaft, as the engine is set slightly on the skew to counteract propeller torque.

A "wash-out" is given on the port main planes when the machine is fitted with a left-hand tractor, and on the starboard main planes when a right-hand tractor is fitted.

The incidence on the plane on the side "wash-out" is given should be 4° 30′ (4½°) at centre section; 4° 22½′ at intermediate strut, and 4° 15′ at outer strut.

The incidence of the main planes on the opposite side to that on which the "wash-out" is given, is 4½° throughout both upper and lower planes.

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The incidence wires should be tensioned after the final adjustments for the "wash-out" have been made.

The straightedge should touch the lowest point of the rib which is slightly behind the leading edge and the rear spar, when the incidence is being measured. The incidence of the upper main plane should not be measured at the root, or on the rib next to the root, as these ribs are modified in order to make a satisfactory joint with the centre section plane.

After truing up the main planes, the drag and anti-drag wires should be adjusted. These should not receive quite so high a tension as the flying wires, but they should not be slack.

In fixing the flaps, straightedges should be held underneath the main planes so that the upper edge of the straightedge touches the lowest point of the main plane rib near the leading edge, the rear spar of the main plane, and the trailing edge of the flap. The flaps on both upper and lower main planes should be fixed at the same time and held in the above position, the control cables passing from the lower flap levers to the lower flaps being then connected up and adjusted as may be required by means of the strainers on the cables. The upper flaps are then adjusted by the two Aeroflex cables, which connect the pair of flaps on each side of the fuselage, the cables being connected by the quick release attachments with which they are fitted, and the turnbuckles adjusted as may be required.

Tail Unit :

6. Adjust tail trimming gear so that in bottom position incidence is 1°, and in top position 5½°.

Controls :

7. Controls should be adjusted to figures in table.

With the camber control flaps down at an angle of 12°, the travelling nuts on the actuating screw should be as far in towards the centre as possible, and the camber control cables should be just tight.

With the rudder pedals square in the fuselage, the air and water rudders should point directly for and aft.

Note.—This aircraft can also be used as a land chassis.

F.5 FLYING BOAT.

(EAGLE VIII.)

RIGGING NOTES.

Rigging Position :

1. The aeroplane is in rigging position when the top longerons between side struts No. 1 and the sternpost are level longitudinally, and the centre section lower plane spars are level transversely.

Hull :

2. The front portion of the hull, as far as the rear spar, will not need truing. The hull sides at the rear are permanently covered with 3-ply or diagonal planking, so that the side cross bracing wires cannot, in the ordinary way, be adjusted.

Clamp two straightedges transversely across the upper faces of the top longerons, one above side struts No. 1 and the other above side struts No. 6. Stretch two lines between the lower edges of the two straightedges, one on each side of the hull and about 3 ins. outside the longerons, roughly parallel to them. The upper faces of the top longerons will be in the same horizontal plane as the stretched lines when the hull is true.

Mark the midpoints of all the top transverse struts, and clamp a straightedge horizontally across a pair of ribs in the prow of the boat, midway between the upper longerons and the keel. From the middle point of the straightedge, stretch a line to the sternpost. This line will be the longitudinal centre line of the hull in plan. Adjust the cross bracing wires until corresponding diagonals in each section are equal, and adjust the top cross bracing wires until the midpoints of all the top cross struts and the inner stretched line are in the same vertical plane. Check by dropping plumb lines.

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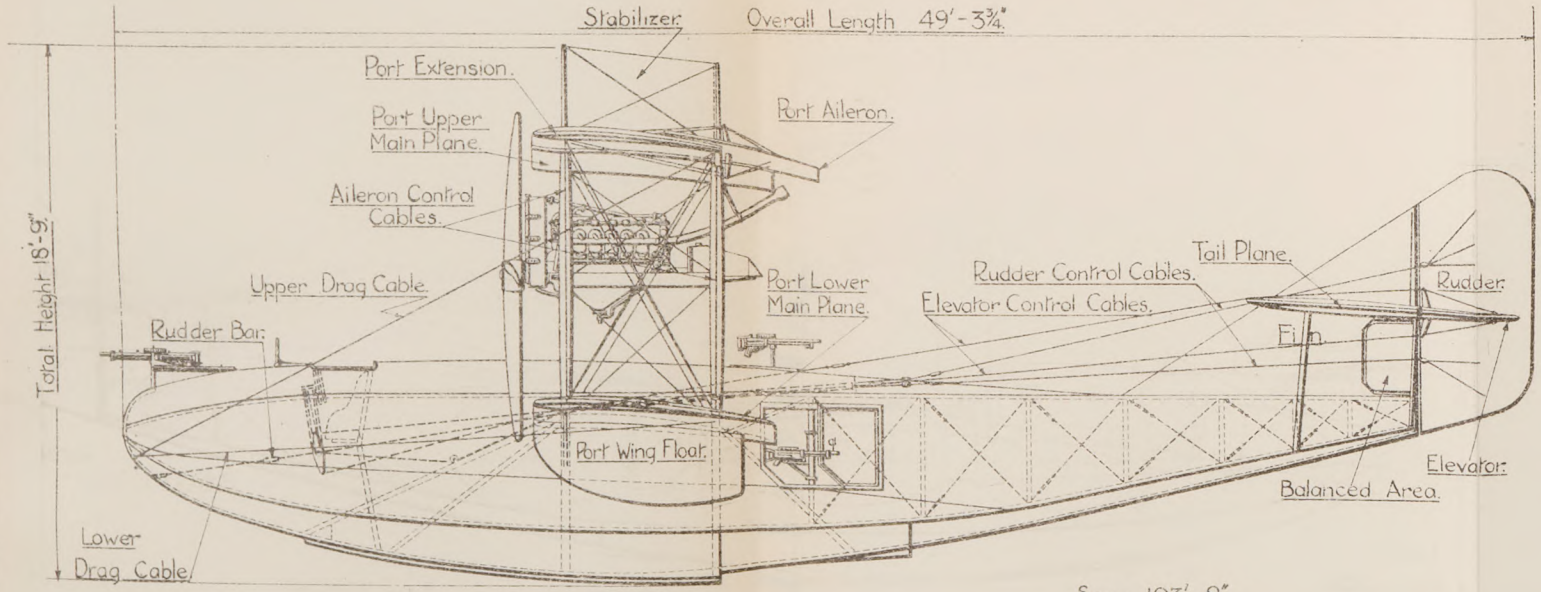
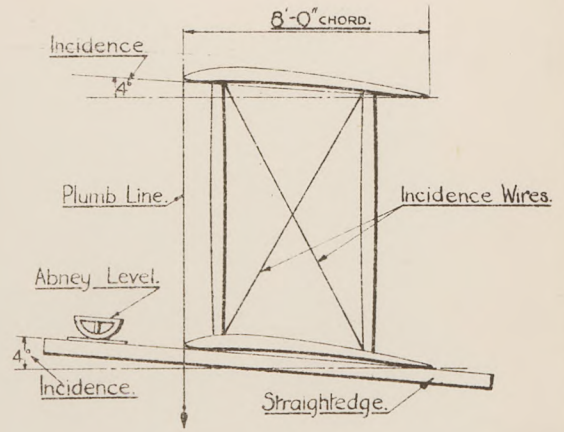
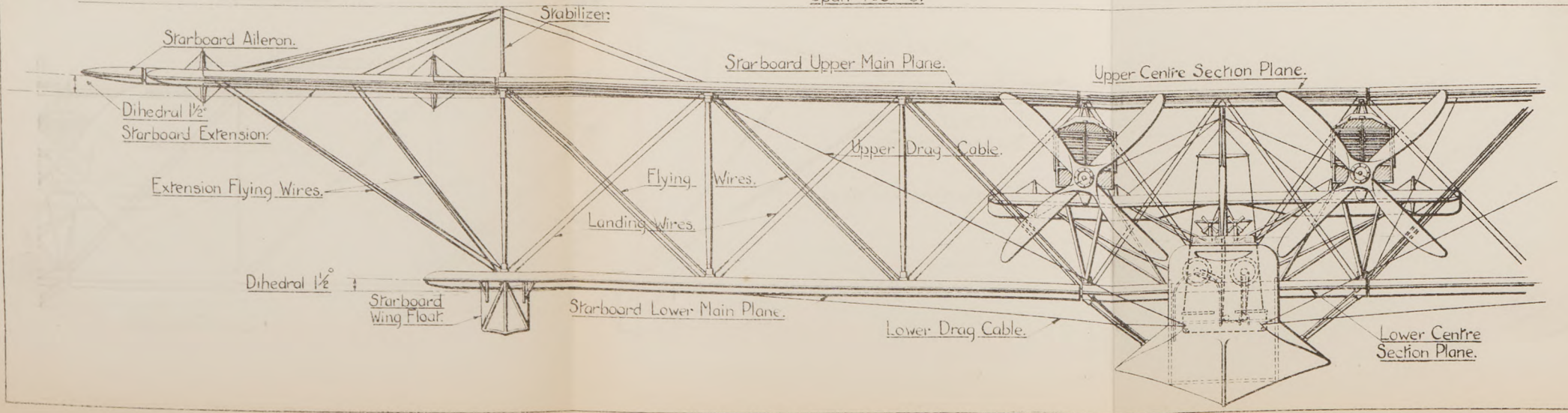
F. 5. BOAT SEAPLANE.
2-ROLLS-ROYCE EAGLE VIII.

FIG. 90.







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Centre Section :

3. First erect the pair of centre section struts, loosely attaching the incidence, landing and flying wires. Then erect the engine lower "V" struts, front and rear, on each side, and hoist the engines into position Erect the upper "V" struts, fit the upper plane, and fix up all the remaining bracing.

To true up, first make sure that the central struts are vertical, whether viewed from the front or side. The centre section should be symmetrical about the vertical centre line of the seaplane when viewed from the front. Adjust until the upper centre section spars, front and rear, are horizontal throughout, and plumb lines dropped from the four corners of the upper plane just touch the corresponding points on the lower centre section.

Main Planes :

4. Assemble the main planes with their leading edges on the ground, all interplane struts being fitted, and all bracing wires attached, but not tightened up. (The extension planes are fitted later.)

Hoist the planes into position, inserting the roots of the spars in the fish plates on the centre section, and insert the bolts. Connect up all bracing wires.

Attach the upper main plane extension by means of the fish plates provided, supporting the extensions by means of the bracing wires attached to the stabiliser and to the upper main spars.

To true up, first make sure that the leading edges of the main planes are at right angles to the centre line of the hull by dropping plumb lines at frequent intervals and sighting. Then adjust the top and bottom drag wires until the following measurements are similar on each side :—

(*a*) From bottom sockets of front outer struts to front drag wiring plates.

(*b*) From bottom sockets of front outer struts to stern end of keel.

The dihedral is 1½° for both upper and lower planes. There is no stagger, and the incidence is 4° throughout, both upper and lower main planes. Measure by straightedge and incidence protractor.

Adjust wires so that extension spars are in line with main plane spars, and fin is vertical. Great care must be taken not to over-tension the flying wires and auxiliary flying wires attached to the extension plane, as this would cause initial stress in the extension spars or outer interplane struts.

Empennage :

5. The fin should be vertical and point directly fore and aft. After placing the tail plane in position, attach the tubular stays, and adjust bracing wires until the spars are level transversely and are square with the hull. Check for squareness by measuring from the joint between centre section rear spars and hull to the tip of the tail plane rear spar on each side. Corresponding measurements should be equal.

The angle of incidence of the centre line of tail plane is 2¼°.

Controls :

6. Adjust controls so that :—

(*a*) With pilot's control central, the ailerons droop ¾ in.

(*b*) With pilot's control inclined forward 10°, the elevators are in line with the tail plane.

PARNALL PANTHER N.2.A.

(B.R.2.)

Rigging Notes.

Rigging Position :

1. The fuselage is in two portions, hinged so that the rear portion can be swung round to fold aeroplane when required.

The aeroplane is in rigging position when the spars in the fuselage are level transversely, and the chord of the lower section rib is inclined upwards at an angle of 2°.

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Aeroplanes are provided with two datum marks on the plywood skin, one just below the bottom of each centre section strut. A cord stretched across these datum marks should be level longitudinally.

Fuselage :

2. Support the front portion of the fuselage on two trestle cradles, one placed under the gunners' cockpit, and the other under the front frame.

Lift the rear portion into position, and insert the securing pins into the hinge joints, at the same time placing a trestle cradle just in front of the tail skid.

Both portions of the fuselage are of rigid construction, so that no further alterations in the truing up are possible.

Undercarriage and Hydrovane :

3. Place the undercarriage in position by attaching the tops of the undercarriage struts to the pin joint fittings on the fuselage, and connect up the streamline wires.

To true up, adjust the cross bracing cables until corresponding diagonals are equal, and check by dropping a plumb line from the fuselage cross member over the axle to a mark which will be found on the undercarriage axle strut. This plumb line should strike the centre of the axle.

The wooden fairing between the undercarriage bracing cables should now be fitted. After the undercarriage has been checked for symmetry, the hydrovane should be erected by attaching the tops of the hydrovane wooden struts to the fittings on the fuselage, and the horizontal metal struts to the axle end of the front undercarriage struts. The hydrovane should be checked for symmetry by dropping a plumb line from the centre of the engine frame and lining in the centre point of the hydrovane cross strut and the centre point of the undercarriage axle strut with this plumb line. The incidence of each side of the hydrovane will be about 4°. The aeroplane may now be blocked up under the undercarriage struts, and the wheels attached. To do this, the internal axle springs must be compressed while the wheel is placed in position and the securing pins inserted.

The release cable for the securing pins is then carried to the pilot's seat, and connected up to the control lever.

Centre Section :

4. Attach in usual way.

Main Planes :

5. Attach the lower main planes to the fittings on the lower centre section, supporting the wing tips on trestles. Connect up landing wires on both sides.

Fit the interplane struts into their corresponding sockets on the upper main planes; lift the unit into position; attach the interplane struts to the lower main plane fittings, and the upper main planes to the fitting on the upper centre section.

Connect up the flying wires.

There is a " wash-in " of ¼° on the port main planes, and a " wash-out " of ¼° on the starboard main planes, so that the incidence measured at the interplane struts will be 2¼° on the port side, and 1¾° on the starboard side.

Adjust by incidence and rear landing and flying wires, and check by incidence gauge placed across the main plane spars, under the interplane struts.

Empennage :

6. The incidence of the tail plane should be 1° measured on the centre line of the spars.

The fin is integral with the tail plane, and is braced by one strut on each side. The finpost leans forward 17° when the fuselage is in rigging position.

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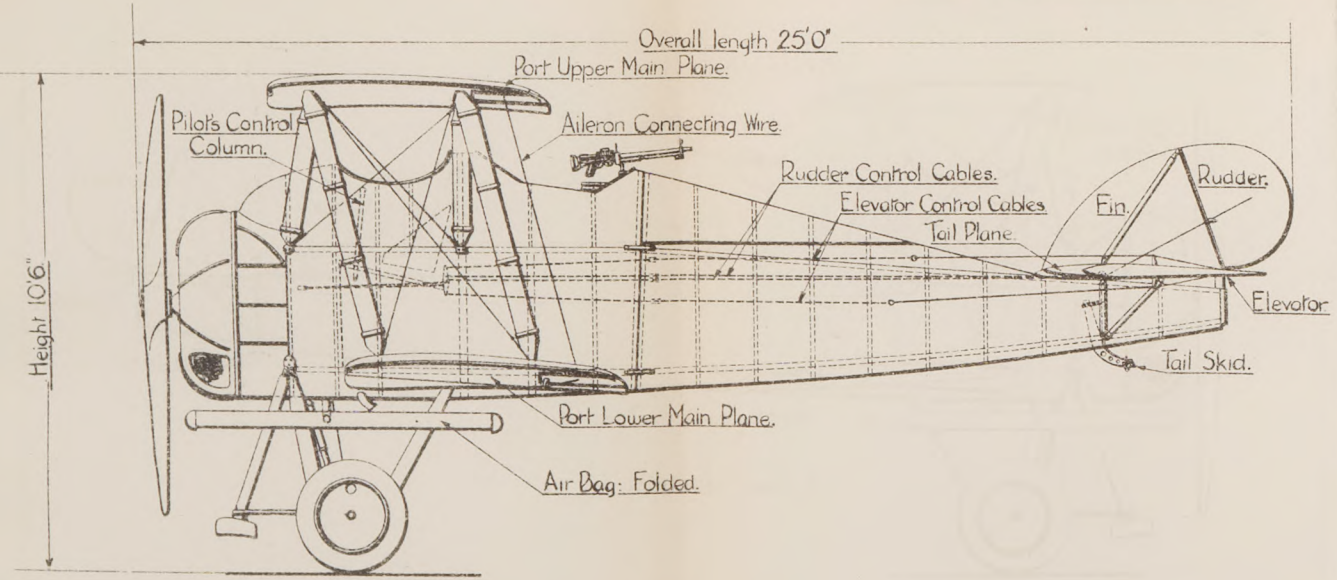
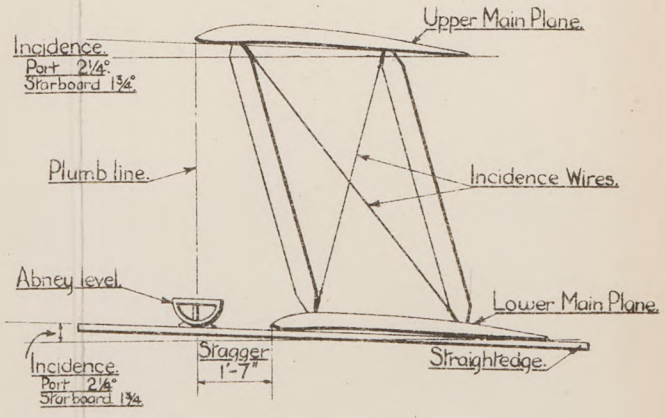
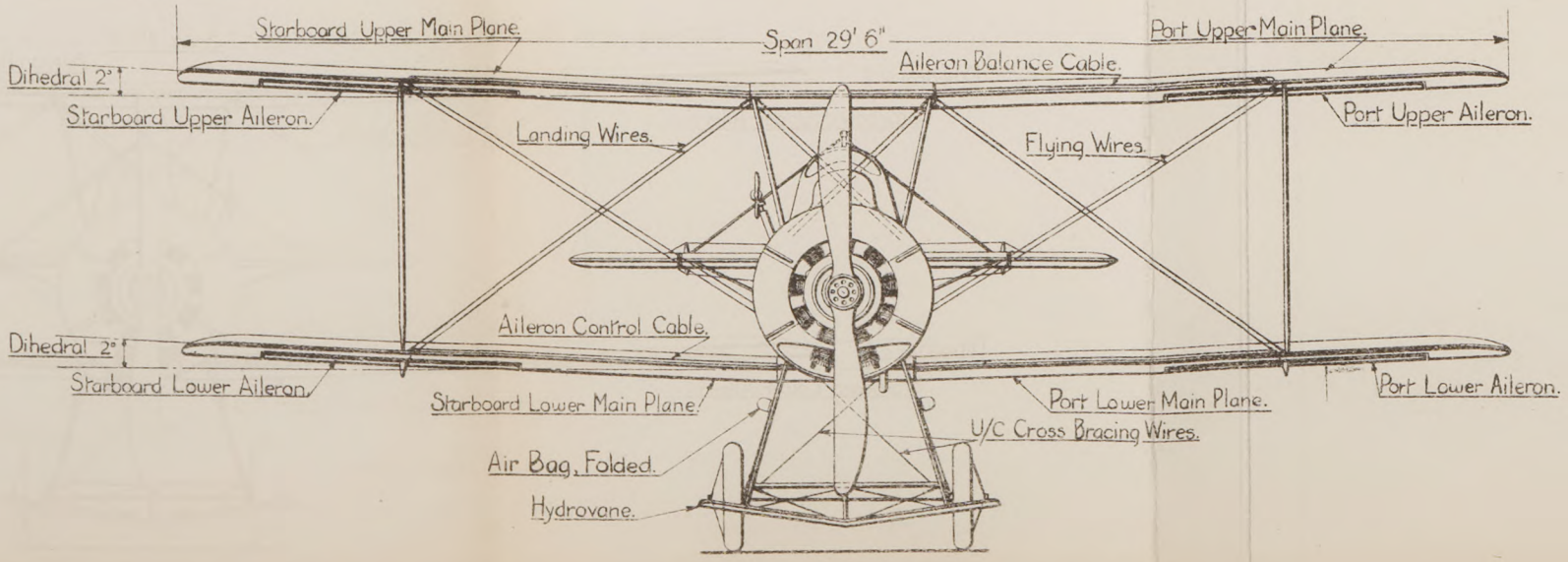
PARNALL PANTHER N2A.
200 H.P. B.R.II.

FIG.







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Controls :

7. Adjust to figures shown on table.

The rudderpost is inclined forward 17° with the machine in rigging position.

In order to enable the empennage control cables to be detached for splitting the machine, quick release fittings are attached to these cables inside the gunner's cockpit, and in connecting up these controls it is necessary to ensure that these fittings are securely locked.

Air Bags :

8. Air bags are fitted at the rear end of the fuselage. Each of these bags is connected by piping to an injector placed in the pilot's cockpit. The bags are inflated with air, which is stored under pressure in a bottle and passed into the bags at atmospheric pressure through the injector.

The air bag in the rear portion of the fuselage is attached to a plywood board which is readily removable, while those on the undercarriage struts are attached to spars which in turn are bolted to the undercarriage and hydrovane struts. These spars require to be fixed into position before the piping connections are made. A system of interlocking is used, whereby one lever is made to operate consecutively the release for the wheels and the inflation of the air bags.

Folding the Aeroplane :

9. Support the aeroplane on two trestles, one placed under the pilot's cockpit, and the other under the airscrew shaft.

Detach the securing bolts on the port side of the fuselage, and swing the tail of the aeroplane round until the tail plane is in position between the main planes.

The aeroplane may be locked in the folded position by securing the starboard fin strut to the interplane struts. If it is required to move the machine after it has been folded great care should be taken to see that it does not overbalance fore and aft.

Packing and Transport :

10. For packing purposes the aeroplane is dissembled by detaching the rear portion of the fuselage, the hydrovane gear and the airscrew. It may now be packed in two carriage waggons by placing the front portion of the fuselage, wings and undercarriage in one waggon, and the rear portion of the fuselage, hydrovane gear and airscrew in the other. For road transport, the rear portion of the fuselage is detached and the aeroplane mounted on a lorry. For this purpose it is necessary to ensure that the front portion of the fuselage is securely locked fore and aft, and that the wheels and undercarriage are properly anchored.

Special " V " struts, which are attached to the front and rear of the lorry, must be attached to the fittings on the under side of the lower main planes at the front interplane struts.

SOPWITH SNIPE 7.F.1.

(B.R.2.)

Rigging Notes.

Rigging Position :

1. Support aeroplane under struts Nos. 2 and 9.

The aeroplane is in rigging position when the top longerons between side struts Nos. 1 and 4 are level transversely and longitudinally. The spars at the bottom of the fuselage also will be level transversely.

Fuselage :

2. The side struts are numbered from front to rear.

Mark points 15½ ins. vertically below the upper surface of the top longerons on side struts Nos. 1 to 4, inclusive, and on the remaining side struts mark the following distances respectively below the upper surface of the top longerons :—Side struts No. 5, 14$\frac{15}{16}$ ins.; No. 6, 13¼ ins.; No. 7, 11$\frac{7}{16}$ ins.; No. 8, 9$\frac{5}{8}$ ins.; No. 9, 7$\frac{7}{8}$ ins., and on sternpost, 6 ins.

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Mark the mid points of all top and bottom struts.
Align the marked points in the usual way.

Undercarriage :

3. To adjust, mark points on the ends of the short projecting tubes on the undercarriage struts, under which the shock absorber is wrapped, and from these points mark equal distances, say 3 ft. 6 ins. up each strut, and adjust by the cross bracing wires until the diagonals between the marked points are equal. Check by trammel. A fibre block is inserted between the streamlined cross bracing wires in order to keep them apart. This should always be replaced after truing up.

The axle is hinged at the centre, and this point is connected to a wiring plate on the back engine plate by a vertical bracing wire, which takes the load when the aeroplane is landing. This bracing wire should be tensioned until the two portions of the axle are in line.

The shock absorbers on each wheel are formed by 20 ft. of $\frac{5}{8}$ in. diameter elastic, which is given 14 complete turns round the axle. The ends of the elastic are lashed with balloon cord and turned into the centre.

Centre Section :

4. Fix in usual manner.

Main Planes :

5. Assemble in the usual way.
There is no "wash-in" or "wash-out."

Empennage :

6. The incidence of the tail plane can be adjusted from the pilot's cockpit.

When in the forward position the adjusting tube is lowered as far as possible, giving a maximum incidence of 6° to the tail plane. With the control lever in a neutral position, the incidence is 3°, and with the lever in the aft position a minimum incidence of 1° 20′ is given.

The guard of the pulley at each end of the quadrant has a $\frac{1}{8}$ in. pin brazed on. In assembling the adjusting gear it is of great importance that this pin should engage with a $\frac{1}{8}$ in. hole provided in the quadrant, so as to prevent the guard of the pulley from rotating and so jamming the controlling cable which passes round the pulley.

Fit the rudder to the three hinges on the sternpost. The lower hinge is the setting hinge, the others having $\frac{1}{16}$ in. clearance.

The fin should point directly fore and aft and be square with the aeroplane.

Hinge each elevator to its three hinges, inserting the nuts and bolts, and not forgetting the split pins. The outer hinges are the setting hinges, all others having a clearance of $\frac{1}{16}$ in.

The shock absorber on the tail skid is formed of 10 ft. of $\frac{3}{8}$ in. diameter elastic, which is given 6 complete turns (*i.e.*, 12 strands in a section taken through the middle), and secured by balloon cord wrapped in three places.

Controls :

7. Adjust the controls to figures in table.

VICKERS VERNON.

(EAGLE VIII.)

RIGGING NOTES.

Rigging Position :

1. The assembled fuselage should be supported on two adjustable trestles, the height of the front one being approximately 4 ft., and the centre line of the aeroplane (which is just below the level of the bottoms of the cabin windows) is roughly level. The front trestle should support the fuselage in the space reserved for the front petrol tank, and the rear trestle at a point about $17\frac{1}{2}$ ins. from leading edge of tail plane, under a strong bulkhead.

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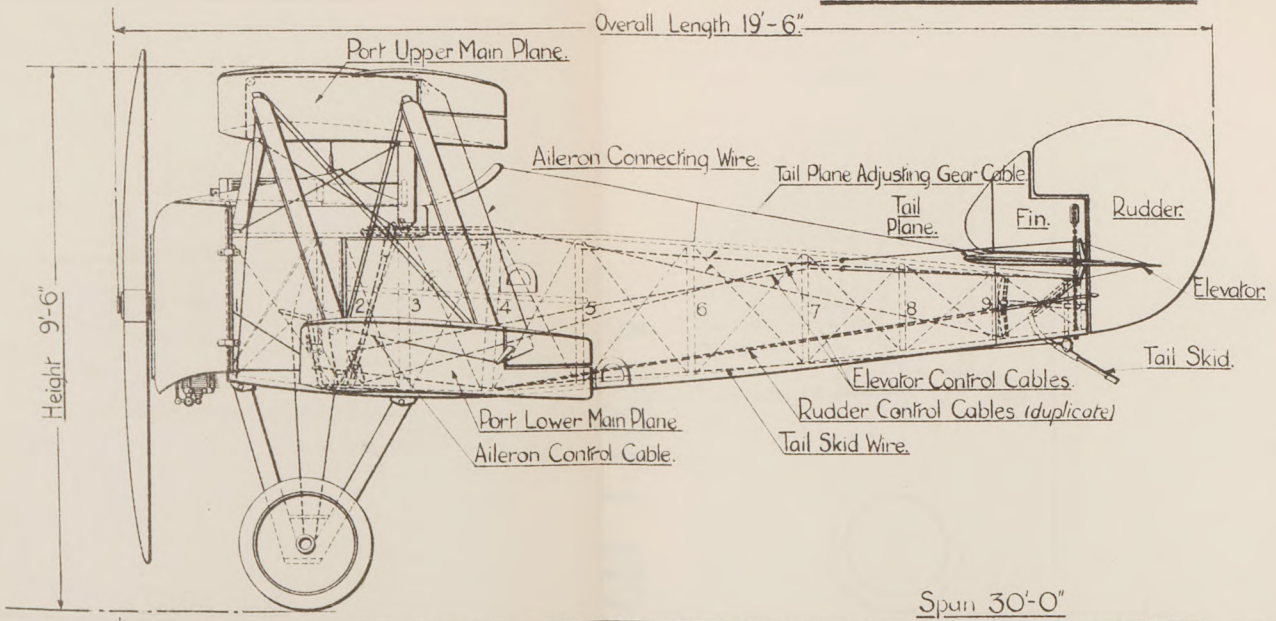
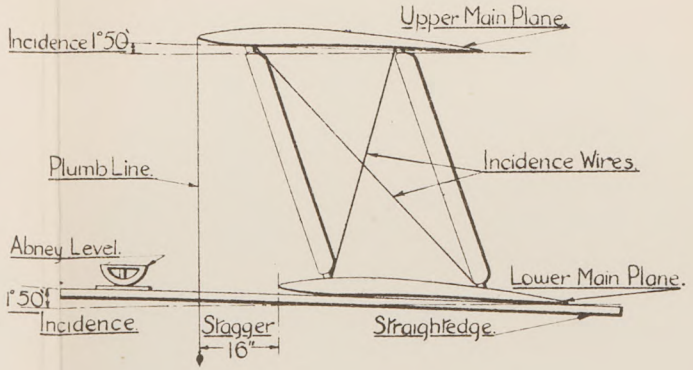
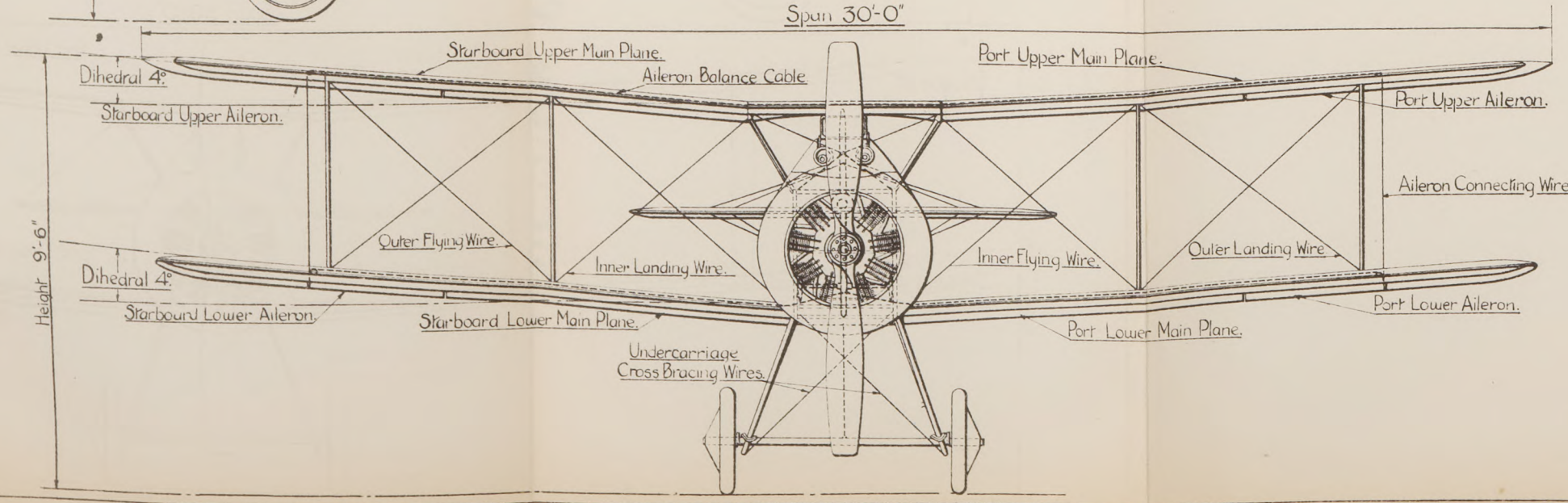
SOPWITH SNIPE 7F1.
200 H.P. B.R.II.

FIG. 92.







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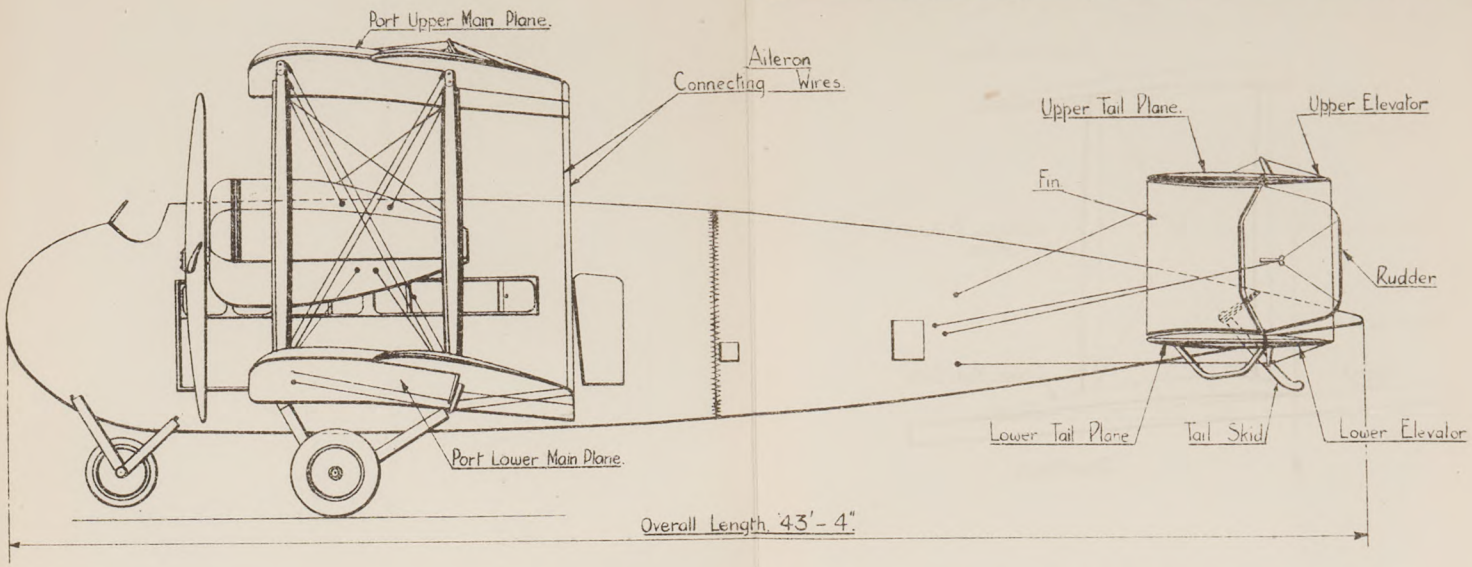
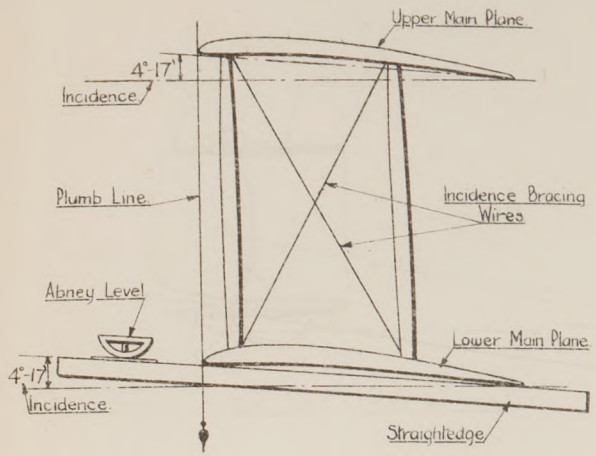
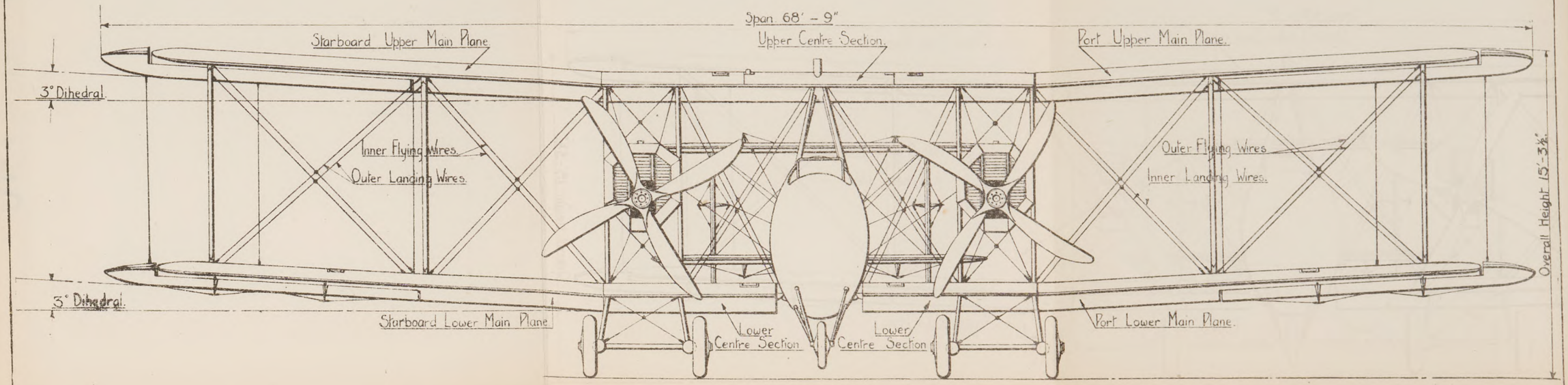
VICKERS VERNON.
2 - ROLLS-ROYCE EAGLE VIII.







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The aeroplane is not placed *exactly* in rigging position until the lower centre section is fitted. At this stage, the control cables, front landing wheel, tail skid, internal fittings, etc., should be installed in the fuselage.

Fuselage :

2. The fuselage is built in two portions. The front comprises a cabin built up of formers and plywood. The rear portion consists of wooden longerons and struts built up on the Ryan principle.

The two portions are joined by means of four pin joints, which do not permit of adjustment. Both parts of the fuselage are assembled in jigs, and, therefore, no truing up of the fuselage is necessary, or possible.

Centre Section Planes and Undercarriage :

3. Support each portion of the lower centre plane by trestles placed under the ends, and attach the tops of each pair of undercarriage " V " struts to the plane spars in their proper positions. Wheel each unit (lower centre plane with its undercarriage) into position near the fuselage and insert the pins which join the lower spars to fuselage. To do this, the fuselage trestles may require slight adjustment.

The engines, each borne on its " bedstead " of four vertical steel tubular struts, are next hoisted into position, and the lower ends of the four tubes joined to the corresponding points on the plane.

Next hoist the upper centre plane, to which the two cabanes and all wires have been attached, into position, and complete all joints, leaving wires connected but not finally tightened up.

The front trestle under the fuselage may now be removed, allowing the weight of the front portion of the fuselage and of the centre section and engines to be borne by the undercarriage.

The axles of the two undercarriage units should be in line, and this line should be at right angles to the longitudinal axis of the machine.

Adjust the undercarriage bracing wires so that each unit is symmetrical when viewed from the front.

The centre section should be horizontal and symmetrical about the vertical centre line of the machine when viewed from the front. Get the lower centre sections horizontal by placing jacks under the streamline fairing of the shock absorber. Check with level.

Raise or lower the remaining fuselage trestle (near the tail) until the incidence of both port and starboard lower centre planes is 3½°.

Adjust all bracing wires until the following conditions are fulfilled. (The measurement of incidence and the transverse levelling of the lower centre planes have already been done.)

(1) The incidence on the upper centre plane is also 3½°.
(2) The upper plane is transversely horizontal.
(3) Plumb lines dropped from the front and rear, port and starboard outer corners of the upper centre plane just touch corresponding corners of the lower planes.
(4) The engine bearers on both port and starboard are horizontal, both longitudinally and transversely.
(5) All bracing is taut.

The centre section will then be true.

At this stage, engine controls between fuselage and engines should be coupled up.

Main Planes :

4. Mount one of the lower main planes on trestles and attach the two inner landing wires, adjusting each to 145·7 in. in length. Repeat for the other lower plane.

Assemble the upper plane complete with its four interplane struts and all bracing wires. Hoist into position, and make the necessary joints. Remove the trestles and adjust the main planes.

Empennage :

5. The two portions of the tail plane are first fixed to the fuselage by the attachments at the spars ends. The rear spar fits over a short length

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of tube, which screws into the last horizontal bottom cross tube of the fuselage, thus allowing a certain degree of lateral adjustment.

The front spar is pinned to a vertical fuselage strut in one of the positions provided by the four holes. For the normal setting, the third hole from the bottom is employed.

Next assemble (on the ground) the upper tail plane, complete with its elevator, the cabane struts, fins and bracing wires. Hoist this unit into position and fix.

Attach rudders and the lower elevator.

Controls :

6. Couple up all controls, and adjust to figures shown in table.

VICKERS VIMY.

(EAGLE VIII.)

RIGGING NOTES.

Rigging Position :

1. Support the complete fuselage on two trestles, one being placed under the front of the pilot's cockpit, and the other under side struts No. 8.

The aeroplane is in rigging position when the top faces of the top longerons are level throughout, both longitudinally and transversely.

Fuselage :

2. When the front portion is assembled, no further truing up is possible as all the joints are pinned and sweated together.

The rear portion is assembled as a separate unit. For this purpose the struts of this portion are numbered from front to rear, No. 1 strut occurring at the front of the rear cockpit, and No. 10 being at the tail end.

Place the section on two trestles, one each under side struts Nos. 2 and 8 respectively, and pack up until the top longerons are approximately level.

Mark points 12 ins. vertically below the upper surface of the top longerons on all side struts from Nos. 1 to 10 inclusive.

Mark the mid points of all top and bottom transverse struts.

Align the marked points in the usual way.

When the rear portion has been carefully squared and trammelled, the wo portions of the fuselage are joined together. The whole fuselage is then placed in rigging position, and final adjustments carried out.

Undercarriage :

3. The undercarriage is in two parts, which are similar in construction and placed so that one part comes under each engine.

Attach the tops of each pair of " V " struts to the lower centre section plane spars. Tension the cross bracing wires between the undercarriage " V " struts.

The axles of the two portions of the undercarriage should be in line, and this line should be at right angles to the longitudinal centre line of the machine.

The undercarriage frame is rigid longitudinally and does not permit of adjustment.

The shock absorbers on each wheel are formed by two coils of elastic each coil consisting of 22 ft. 6 ins. of $\frac{1}{2}$ in. diameter elastic.

After the undercarriage has been attached, packing blocks may be placed under the " V " struts to take up some of the extra weight when the engines are fitted.

Centre Section :

4. Place each portion of the centre section lower plane in position, and support the outer ends on trestles.

Connect the tops of the centre and engine bearer struts to the sockets on the centre section upper plane. Lift the centre section upper plane complete with struts into position, and loosely connect the bracing wires

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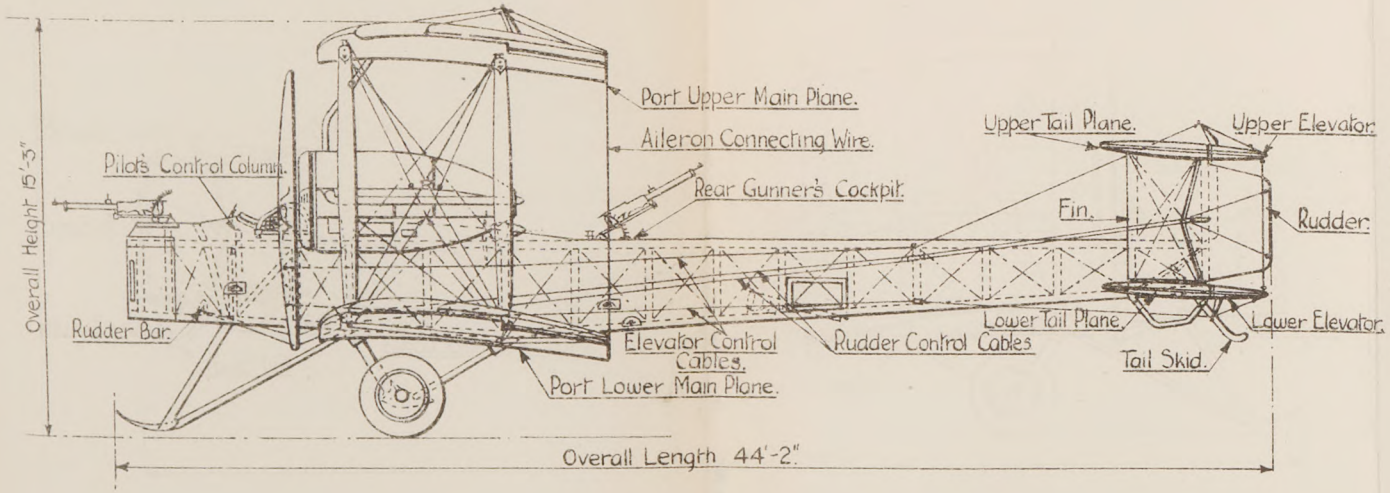
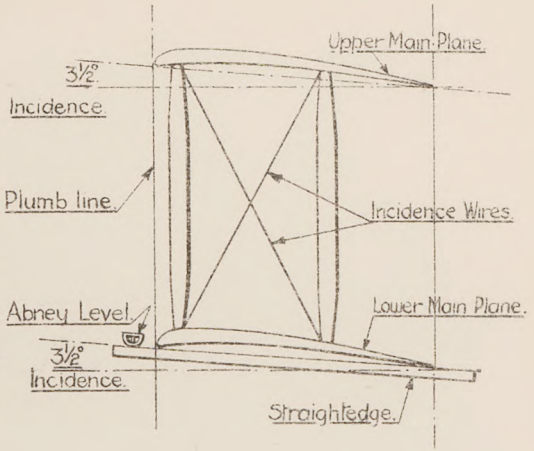
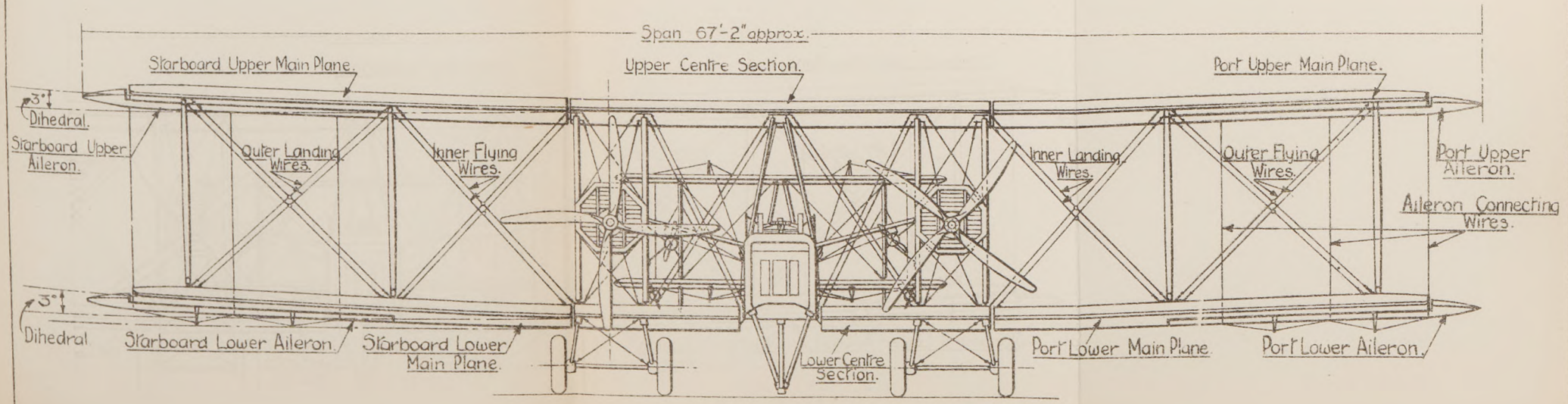
VICKERS VIMY.
2-ROLLS-ROYCE EAGLE VIII.

FIG. 94.







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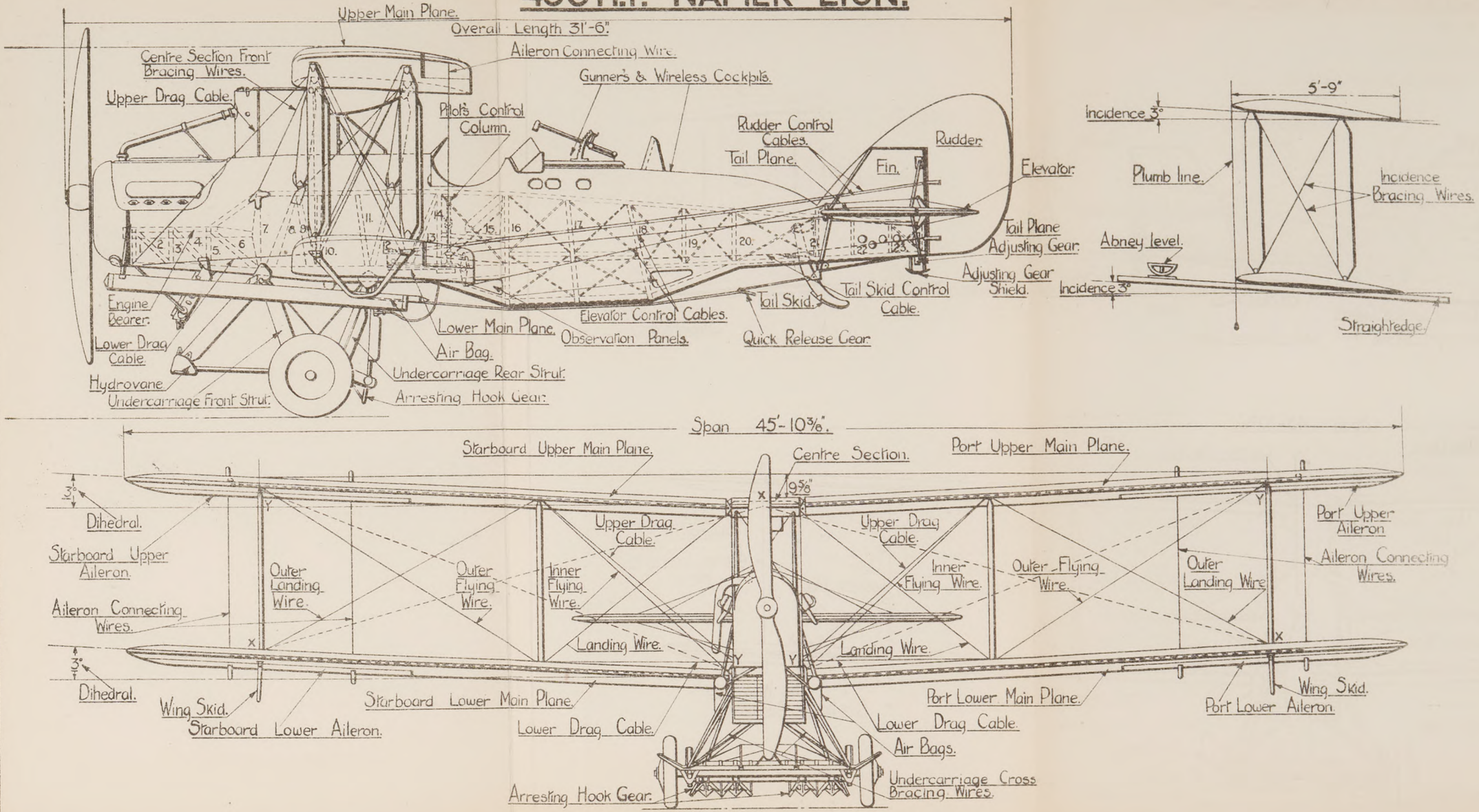
WESTLAND WALRUS.
450 H.P. NAPIER LION.

FIG. 95.



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Engines :

5. Before fitting the engines the whole centre section and undercarriage must be braced up, with the exception of the front cross bracing in the engine bays. Lift the engines into position and make all connections.

Main Planes :

6. Assemble and attach in usual manner.
There is no " wash-in " or " wash-out."

Empennage :

7. The rear spars have tubular fittings, which slide over and are pinned to corresponding fittings on No. 10 fuselage bottom cross strut. By means of the screw arrangement on this fitting, the tail plane can be adjusted so that the spars are square with the longitudinal axis of the aeroplane.

The front spar of the tail plane has its end attached to No. 9 side strut of the fuselage, and in this case a bolt passes through the spar end fitting and a hole in the side strut. Four such holes are drilled in this strut, which permit of four separate settings of the tail plane incidence. For trial flight the bolt should be passed through the next hole to the bottom one in the strut.

The upper and lower tail planes may be assembled together and attached to the fuselage as one unit by the fittings previously described, and the inverted " V " struts over the fuselage.

Adjust the tail plane incidence wires, until the incidence on the upper tail plane is the same as that of the lower tail plane.

The tail plane struts should be vertical when viewed from the front and side.

The tail-skid is non-steerable, but is free to rotate on a special fitting in the centre of No. 10 bottom cross strut of the fuselage.

The shock absorber on the tail-skid is formed of 33 ft. of ¼ in. diameter elastic. It is given four complete turns (*i.e.*, eight strands in a section taken through the middle), and secured by balloon cord wrapped in two places. Metal guides are attached to No. 10 top cross fuselage strut, and the elastic is passed through the guides and round the top of the tail-skid.

Controls :

8. Adjust controls to figures in table.

WESTLAND WALRUS, TYPES I. AND II.

(LION.)

RIGGING NOTES.

Westland Walrus I. has wings of R.A.F. 15 section.

Westland Walrus II. has wings of R.A.F. 64 section, and differs from Type I. in certain dimensions.

Rigging Position :

1. Support the fuselage at the tail skid on a trestle, and adjust until a straightedge placed on the two rigging blocks attached to the port side three-ply near the centre section struts is horizontal. To level transversely, pack up the undercarriage by means of jacks or blocks under the "Vs," until a straightedge placed across the upper longerons between the rear centre section strut attachments is horizontal.

Fuselage :

2. The sides of the fuselage are rigid and contain no adjustable bracing so that the fuselage will be true when the middle points of all upper cross struts are in the same vertical plane as the corresponding middle point of the lower cross struts.

Undercarriage :

3. The undercarriage should be symmetrical about the vertical centre line of the aeroplane when viewed from the front, and the axle at right

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angles to the longitudinal axis of the fuselage. Adjust the cross bracing wires until equal, and check by trammel. This is all that is necessary in the case of the oleo undercarriage, but for the standard "V" type the fore and aft position of the axle must be checked. Adjust the side cross bracing wires until a plumb line dropped from a point 22¼ ins. in front of the centre point of the rear undercarriage to longeron fitting just touches the middle of the axle on each side.

The kingpost bracing wires on both hydrovane and axle must be left slack.

Tail :

4. For trial flight the bobbin of the tail plane adjusting gear should be in the middle of the screwed sleeve on the vertical steel tube.

Adjust the bracing wires so that the tail plane is laterally horizontal; check by spirit level placed on rear spar. Check for squareness with fuselage by making the distances between the ends of the tail plane spars and the main plane rear spar fittings on the fuselage equal on each side. See that the fin and rudder are vertical and point directly fore and aft with rudder bar square in fuselage.

Centre Section :

5. There is no stagger in the case of Walrus I., but the Walrus II. has a positive stagger of 7 ins.

The centre section of both types will, of course, be symmetrical when viewed from the front. For the Mark I. aircraft, adjust longitudinally by the side bracing wires, and drop plumb lines, which should just touch the corresponding points of upper and lower spar attachments, front and rear. For the Walrus II. there should be a horizontal distance of 7 ins. between the plumb lines and the lower spar attachments.

Main Planes :

6. Adjust to 3° incidence throughout and 3° dihedral for both types. Compare the distances between bottom sockets of front outer interplane struts and the bottom of tail plane adjusting tube on each side. These lengths should correspond.

Controls :

7. Give the ailerons ¾ in. droop, with control column vertical.

27. Points to Observe When Overhauling Aeroplanes.

1. See that the Main Planes are symmetrical about the centre line of aeroplane.
2. See that all lock nuts for Bracing Wires are tight.
3. Check the Dihedral.
4. Check the Stagger.
5. Check the Incidence.
6. See that the Interplane Struts are straight, undamaged and streamlined in the direction of flight.
7. Examine all Main Plane Bracing Wires for length and tautness, and see that all Split Pins are in position.
8. Examine all Controls, Pulleys and Cables and see that they work freely, and that all Turnbuckles on Cables are locked.
9. Examine the Tail Plane Adjusting Gear if fitted.
10. Examine the Tail Plane and see that it is set correctly and is square with aeroplane, and that all Tail Plane Bracing Wires are correct both as to length and tautness, and that all Split Pins are in position.
11. Examine the Rudder and Skid and see that they are set vertical and in correct position.
12. See that the Elevators and Ailerons are set in correct position.
13. Examine Tank mounting and connections.
14. Examine Engine Mounting, Engine Controls and Engine Accessories.

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28. Picketing Aeroplanes in the Open.

1. In securing an aeroplane the following main points should be observed. The aeroplane should be :—

(*a*) Head to wind.
(*b*) Completely rigged (*i.e.*, as for flying).
(*c*) The tail raised as high as possible (in order to reduce the angle of the main planes and so reduce their lift).
(*d*) Secured in such a way that it cannot move :—
(*a*) Backwards or forwards.
(*b*) Rock from side to side.
(*c*) Slew to the right or left.

2. These points are dealt with in detail below :—

(*a*) *Head to Wind.*—Any other position would result in control surfaces, extensions, or some other part, becoming strained and damaged.

(*b*) *Completely Rigged.*—An aeroplane should not be picketed with wings folded.

Control column should be lashed in neutral position.

(*c*) *Raising of Tail.*—In raising the tail advantage should, if possible, be taken of any slope in the land on which the wind blows "up-hill." The object of raising the tail is to prevent the wind from lifting the aeroplane by reducing the angle of attack in the main planes. It is obvious that if lifted sufficiently high it is possible to get a downward pressure instead of upward. For all ordinary purposes in winds of up to 40 m.p.h., five to six feet is sufficiently high to lift the tail skid. Any stout trestle, hedge, bank or lorry will serve on which to place the tail; the support, however, should be solid, and rendered immovable in any direction. For a heavy bombing aeroplane a lorry or trailer will usually be found most convenient, as the aeroplane can then be more easily orientated should the wind change.

Care should be taken that the weight of the fuselage is taken on the *tail skid* and not on the fuselage itself. This is necessary in order that if the aeroplane rocks laterally it will pivot on a central point, and prevent excessive strain coming on to the right or left-hand longerons.

Lash the tail skid so that it cannot raise itself, and cannot slide about on its support.

Secure the fuselage so that it cannot shift from one side to the other should the wind strike it slightly on the side.

(*d*) *Securing the Aeroplane.*—Remember that the action of the wind tends to lift the whole aeroplane, and to drive it *backwards*; lashings, chocks, etc., should, therefore, be arranged to guard against this. It is much more important to place chocks behind the wheels than in front. Lashing should be arranged :—

(i) From a point on either side of the chassis, led forward and secured to pegs to prevent the machine being driven backwards.

(ii) From the airscrew boss on either side, and led forward about 45° so as to hold the aeroplane downwards and help to check any backward movement.

(iii) From the mooring rings on either wing tip, arranged in two spans, one leading forward and one to the rear. (Double lashings are necessary, as they exert considerable steadying influence on the line of the aeroplane and prevent it slewing).

(iv) From the end of the fuselage, led away to either side from the tail skid bracket in four directions. The tail skid itself should be securely lashed to whatever object is supporting it. (If the body on which the tail skid is supported is light, it should be heavily weighted and lashed to the ground with pegs, ropes, etc.)

3. Iron corkscrew pickets cannot be trusted implicitly under any conditions. They are difficult to drive in hard ground, and easily pulled out in soft ground. Always back the pickets with a second picket, securing one to the other. Do not drive the pickets in vertically, but at an angle, with the lashings as far as possible at right angles to the picket.

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4. All lashings on the tail, fuselage, etc., should be rendered as taut and rigid as possible. There is sufficient spring in the tail skid to prevent any possibility of shock, and the safety of the aeroplane depends entirely on the tail being properly secured.

5. Picket ropes securing the airscrew boss and wing tip mooring ropes should be "backed" with heavy weights, petrol cans, barrels or any suitable object.

6. The wing tip lashings should not be too taut. The aeroplane is bound to rock slightly from side to side, and the picketing weights will prevent undue jerks coming on the plane, and will also prevent the pickets being drawn out from the same cause. Wire lashings are better than rope if they can be obtained, as they are not subject to shrinkage from wet.

Protection from Weather.

7. When left in the open, in rain or snow, see that all openings in the fuselage, fabric and wings are properly covered to prevent water from entering the plane or body of the aeroplane. Cloths or cotton waste should be wrapped round the lower end of struts and wires, where they abut on main spars of lower planes, in order to prevent water which collects on the wires, struts, etc., from running down and gaining access to the interior of the plane.

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CHAPTER V.

ENGINES.

29. MAINTENANCE AND RUNNING HINTS.

The following notes cover general principles. Special points concerning a particular engine will be found under that engine, and should be read in conjunction with the notes below.

For more detailed information, the handbooks issued on particular types should be referred to.

STATIONARY AND RADIAL ENGINES.

Daily Routine.

General :

1. Test the engine for soundness on its bearers. Test all main bearer and other external bolts for slackness, and see that all locking devices, unions, etc. are intact.

Test airscrew shaft for excessive play or tightness of bearings by handling airscrew. Examine airscrew for soundness and tightness on boss.

Note that on turning crankshaft the engine is free, and that no sound indicative of internal disorder is audible. Compression of all cylinders must be good and equal. (*N.B.*—If the engine is hot, beware of a kickback during this operation.)

Check over tappet clearances frequently. This must be done when the engine is cold, unless otherwise stated.

With paraffin and a rag or brush, clean exterior of engine, taking particular care to remove all dirt from carburettors and magnetos.

Always cover engine with a sheet of heavy fabric before putting away the aeroplane.

Lubrication :

2. Fill tanks, allowing, in the case of stationary engines, for oil already in sumps. Oil must always be filtered into the tank through a funnel with a fine mesh gauze strainer reserved for this purpose only. This funnel must be hung up out of the way of dust, preferably in a cupboard; it must never be put on the floor.

When making a trial run, note that the oil pressure gauge reading indicates the correct pressure. In cold weather the reading should be so high as to require throttling down of the engine to keep the pointer within the safety zone. If the pressure does not commence to drop after a few minutes' running, the engine should be stopped and the cause of the trouble investigated.

Though no obstruction may exist in the system, it is dangerous to run for longer than the usual time required to warm up, there being a risk of the oil failing to pass some of the smaller ducts and oilways. Look for leaks in pipe system. A low reading on the gauge may be caused by an *air* leak in the suction pipe line, or a faulty jointing washer of the scavenger pump flange.

Ignition System :

3. Use the recommended type of plugs throughout the engine, seeing that they are properly tightened up on sound washers, and that centres of detachable plugs are tight. The spark gaps should be checked and set to a uniform distance, 0·015 ins. being the usual setting. Set the spark gap by bending the earthed electrode, not the centre one.

High tension leads must be properly supported, but the ends must not be taut on the plugs or distributers. Look to the condition of leads and their fixings. The spring clip used on K.L.G. plugs must be fitted with the finger ends towards the plug body, not outwards. Note that plugs are clean externally.

Examine the hand starter magneto and switch leads, noting that the terminals are tight. See that the thimble on the contact breaker earthing terminal clears the spring clip which fixes the cover.

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Look at the contact breaker and feel the fit of the lever on its pivot. The lever should be quite free, but without more than, say, 0·003 in. clearance. The platinum contacts should meet squarely, the gap when full open being between 0·009 and 0·013 in. To clean contacts it is usually best to remove the contact breaker complete. Use a dead-smooth file or very fine emery cloth, leaving one contact flat and the other domed very slightly.

Remove the high tension distributer and clean the brush track with petrol on a rag. Do not use metal polish. If the track is badly scored or burnt, it should be re-cut in the lathe, using a diamond or very keen tool, and taking a very light cut. Spark-gap distributers need only be removed for cleaning about once a week. Check the electrode gap, which should be between 0·008 and ·020 in.

Carbon brushes should be clean, but the glaze must not be interfered with. The N.T. pick-up should be removed at weekly intervals, and the slip ring wiped clean.

Lubricate in accordance with the detailed instruction for the particular system, using clean and fairly thin oil sparingly.

See that the timing control gear works properly, and that all units are correctly synchronised. Where the throttle and timing control are interlocked, the ignition should be fully retarded with closed throttle and fully advanced with throttle about one-fourth to one-third open.

The timing of both ignition systems should be alike, except where special instructions to the contrary are given for a particular engine.

See that magnetos are properly fixed, and that the couplings are in order.

It is important to keep magnetos clean and dry. In continuous damp weather it is often necessary to maintain a constant change of magnetos, the set not on the engine being kept in a warmed chamber to dispel the moisture.

Keep all running switches OFF preparatory to starting, and when running keep both ignition systems on so as to avoid fouling up the plugs not in use.

Coil Ignition.—Study the instructions peculiar to the system in question.

Where no dynamo is fitted to the engine, a freshly charged accumulator must be fitted before each day's flying, the battery removed going on charge at once for the next day.

Maintain the acid level and strength in strict accordance with the detailed instructions.

In the case of the Liberty engine, study the instructions carefully, particularly in regard to the adjustment of the voltage regulator which controls the charging rate.

Carburation :

4. See that the fuel tanks are full; also that no petrol leaks into the fuselage. A tray fitted below the float chambers is the most effective method of preventing this.

Examine all flexible connections in the petrol pipe line; note also that the pipe has not worked loose at any of the securing clips. Check all unions; also see that the piping is free from cracks. Stiff petrol cocks may be eased by use of petrol-proof grease, *e.g.*, Belmoline.

Where more than one carburettor is employed, absolute synchronism in the adjustment of the throttle barrels is essential.

Test the action of the altitude control by noting that the R.P.M. fall when the mixture is weakened by opening the cock. After each day remove the gauze strainer cap underneath the carburettor and clean out any accumulation of foreign matter. Keep an approximate check on the fuel consumption as compared with the specified figure given for the engine.

Petrol must always be filtered through gauze when filling the tank. Filling up must be performed immediately after flight; if left empty overnight, water is liable to accumulate gradually in the tanks as the result of condensation.

Replace filler cap securely, noting in pressure-fed systems that it is air tight, and in gravity-fed, that the vent hole is clear.

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Water Circulation :

5. During cold weather the radiator must be drained off before the aeroplane is put away at night. To ensure that all water is drained off, place the aeroplane in flying position and turn airscrew two or three times. Water drained from the radiator should be kept and used again, thus preventing an undue amount of scale forming in the Water Jackets of the engine and the radiator. Cold water should never be added to a radiator partially filled with hot water, as it tends to cause an air lock.

When filling radiators with fresh water, use rain water if available. Always have the cocks open when filling, until the water issues freely, then close the cocks and wire them securely. Make sure that the radiator cap is firmly screwed down.

6. *Special Precautions during Cold Weather.*—Always drain off water while the engine is still hot. To prevent stiffness when cold, and to facilitate starting, inject a few drops of paraffin into each cylinder whilst the engine is still warm.

In extremely cold weather the oil system must be drained; otherwise, under average winter conditions, it is sufficient to place a catalytic lamp near to the oil pump. Oil warmed to a temperature of 40° to 50° C. should be used for refilling when preparing to start up.

Doping the engine with petrol warmed in hot water will be found to assist starting. Rags dipped in hot water and applied to the induction pipe is a good method of creating preliminary vaporisation, whilst filling the radiator with boiling water will ease an engine in which the lubricant has become congealed through cold.

A suitable anti-freezing solution may be made by mixing one part of methylated spirit to three parts of water. Losses, caused by evaporation during flight tend to weaken the mixture, and these losses may be made good with a mixture of three parts of methylated spirit and one part of water. Losses due to leak or overflow must be made good with solution of the original proportions.

Starting the Engine :

7. Turn on service petrol, and (if fitted) oil cocks.

Test operation of engine controls and switches.

In pressure-fed fuel systems, raise pressure to working value by hand pump, and adjust relief valve to operate at correct pressure.

In hot weather, prime the cylinders sparingly with petrol; in cold weather, slightly more may be required.

Note that all ignition switches are in the " OFF " position.

Fully retard magneto or ignition set distributor.

With throttle about a quarter open, suck in mixture by rotating crankshaft a few revolutions in normal direction.

Leave airscrew to settle, when it will take up starting position. Stand clear of the airscrew, switch on magnetos or ignition set, crank hand starter magneto, or press starting coil push-button, as the case may be.

Run slowly until engine is thoroughly warmed up. Throughout this procedure the oil pressure gauge must be closely observed. (*See* note on lubrication.)

Examine also for leaks in the petrol, oil and water systems. In pressure-fed fuel systems, note that pressure builds up and is maintained.

Having warmed up, open throttle slowly until tachometer shews a reading of about 800 R.P.M.

Pause for an instant to see that all is well, and finally open out to full throttle. On no account allow the R.P.M. to exceed those specified. Engine must only be run at full throttle on the ground for the shortest period for the engine in question.

Note that :—

(*a*) Engine fires regularly without excessive vibration.
(*b*) R.P.M. are satisfactory.
(*c*) All switches are effective.
(*d*) Oil (and fuel if pressure-fed) pressure builds up.

Switch off each ignition unit separately for an instant to test that both sets are working.

Feel over water and oil pipes, checking the circulation therein by noting that temperature is normally maintained.

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In Flight :

8. Note that oil and fuel pressures are maintained.

Keep a constant watch on water temperature. Temperature drops about 1° C. every 1,000 feet of climb.

Note that R.P.M. are maintained and that excessive vibration is not noticeable.

Normal R.P.M. must not be exceeded except for very short periods. Any inclination towards excessive speed indicates that the airscrew is unsuitable, and that it must be changed at the earliest opportunity.

Never operate altitude control below the height specified. This is usually between 5,000 and 7,000 feet.

Always keep all switches on " CONTACT " to prevent sooting of plugs.

Always control engine speed by the throttle, never by the switch.

When descending from high altitude with engine off, close throttle and leave switches on " CONTACT " (except Liberty engines). Set altitude control to " Strong " position if it is not interlinked with throttle control. Also watch fuel pressure gauge. If reading is low after a long descent, at once raise pressure by hand pump.

To stop engine, turn off petrol prior to switching off. This prevents " ticking over."

INSPECTION.

9. In addition to the daily routine, the following more detailed inspection should be made at regular intervals :—

Lubrication :

10. Recharge with grease any greasers that are fitted.

Drain off lubrication system and flush tanks with clean paraffin.

Examine oil relief valve. Note that spring is intact and that valve and seating are in good order. If necessary, grind in and adjust to operate at correct pressure.

Dismantle, clean and replace oil pumps and pipes. Examine pipe line for cracks or leaky unions and note that flange joints of pumps are oil tight. Note that lubrication throughout engine is satisfactory.

Dismantle gauzes and wash in paraffin. On no account may a rag of any description be employed for these operations; a stiff brush only may be used.

After reassembling the oil pump and piping system, or in the case of a new engine, dope the lubrication system through the delivery union with a syringe and oil warmed to 50° C., at the same time doping the pump.

Go over all unions and cocks, noting that they are oil tight, especially looking for possible air leaks in the suction pipe line.

Ignition :

11. Never tamper unnecessarily with the ignition system. Keep things clean, and make the attentions specified only.

Overhaul the ignition apparatus only in strict accordance with the detailed instruction books covering the particular system fitted.

Carburation :

12. Drain off petrol system, and flush tanks, carburettors, pipe work and gauzes throughout with clean petrol.

Examine pipe work for cracks; note that pipes in contact with securing clips or parts of the fuselage are not chafed. Examine soldered joints of pipe unions. Dismantle carburettor, flush through all ducts and passages with clean petrol.

Examine float. If marks indicating considerable wear are noticeable, replace with new one.

Note that joints are in sound condition, especially in the type of carburettor where the choke tube and float chamber are concentric.

Remove jet, wash in clean petrol, and blow through orifices of same, and of diffuser tube. In replacing jets, note that vulcanised fibre washers are correctly replaced, as these affect the height of the petrol in the jet.

Examine throttle and altitude control barrels for soundness of fit in their housings.

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On no account tamper with the calibration of the orifices in the jet, diffuser tube or guard tube. Joints which are spun or solder-made must never be disturbed, the component in question being treated as an integral member.

Examine induction pipe jointing for causes conducive to air leak. Note that flanges are not distorted, and remake joint with fresh packing every time.

Particular care is necessary in examination of flexible connections in the petrol pipe line. If of rubber, they are liable to perish, the broken pieces getting into the pipe line and causing a stoppage. Renew the connections periodically, always noting whether any rubber is missing from inside.

Adjust the slow running jets to give uniform slow running when the engine is warm. The adjustment when cold will in most cases be found to be somewhat richer than when warm. The procedure is to adjust for cold, run the engine for a few minutes till warm, and readjust to run slowly by reducing the strength of the mixture. Having determined this adjustment, give a slight turn towards rich mixture thereby effecting a compromise between the two.

Water Circulation :

13. The water should be drained off at each overhaul, and a solution of warm water and caustic soda poured in. Run the engine with this for about 15 minutes, drain off, fill up with clean water, run for a similar period again, drain off and refill.

(*Special Note.*—Engines with aluminium water jackets must not be treated as above, since soda is detrimental to the jacket. Use instead a solution of warm water, with 30 per cent. paraffin.)

Examine rubber connections at frequent intervals, noting condition of canvas and rubber. Rubber connections should be renewed every three months in tropical countries.

Examine pump. Note especially that no leak is taking place at the stuffing gland. If necessary, renew packing.

Note that radiator is properly insulated from shock. If rubber blocks are used for this purpose, examine their condition.

Examine the interior of water pipes for scale. If the cylinder water jackets are detachable, it will usually be found that scale accumulates most round the exhaust ports. Where possible, this must always be removed.

Test drain cocks for soundness and note that passages are clear.

Examine the water impeller for slackness, and end float.

General :

14. Examine, oil and adjust all moving joints of controls. Inspect for wear, replace where necessary and replenish with grease all Bowden cables.

Remove airscrew and examine condition of boss and shaft. Before replacing, coat the hub taper with a thin film of dry fit anti-seizing compound. Thoroughly examine airscrew and inspect boss for shrinkage. When refitting, tighten evenly the securing bolts and locking nut, replace locking plates or split pin through latter, and test.

Examine valves for compression and fit. Grind in if necessary. Check valve timing after having adjusted tappet clearance.

Never alter adjustments unless justified; the cause of indifferent performance must be properly investigated and the faults eliminated one by one.

Never tamper with magnetos. Keep them clean and dry and make the adjustments previously mentioned only.

Never leave engine uncovered when left standing for any length of time.

Log Books :

15. The importance of correctly entering up log books cannot be overestimated. All engine defects, together with action taken, should be entered in detail. Date on which oil is changed should always be recorded.

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The number of the aeroplane in which an engine is installed should be entered in red ink.

OVERHAUL.

16. Overhauls of stationary engines are classified A. and C. :—

A. Class overhauls are undertaken by Units.

C. Class overhauls are only to be undertaken by repair depôts and schools of technical training.

Top overhauls of stationary engines are necessary after about 100 hours' running, and complete overhauls after about 200 hours.

These times should be considered as a maximum, and not as a hard and fast rule. The running and behaviour of the engine may necessitate overhaul before times stated.

A.—Top Overhaul with Replacements where necessary.

This comprises the following operations :—

(i) Complete external examination.
(ii) Removal and examination of cylinders, pistons and piston rings; decarbonisation.
(iii) Grinding-in valves.
(iv) Removal of engine sump and examination of all big end and journal bearings.
(v) Examination and cleaning of magnetos and carburettors.
(vi) Removal and examination of water pumps.
(vii) Examination of oil and air pressure pumps and, where possible, their removal.
(viii) Examination of reduction gear, airscrew hubs and valve operating gear.
(ix) Examination of all engine controls.
(x) Removal and examination of all sparking plugs and H.T. leads.

C.—Complete Overhaul and Repair by Depôts.

This comprises all the work included under definition "A" with the following additional operations :—

(i) All parts are completely dismantled and thoroughly examined.
(ii) All parts are inspected and conditioned under one of the three following headings :

(*a*) Serviceable.
(*b*) Reparable.
(*c*) Unserviceable.

The parts conditioned as "reparable" are, wherever the necessary plant is available, to be rendered serviceable.

Note.—Normally the replacement of the following parts in stationary engines will be undertaken by repair depôts and schools of technical training only :—

Crankshafts.
Journal bearings.
Epicyclic gear components.
Connecting rods.

C.Os. of Units may, however, in extreme urgency authorise the replacement of these parts. It is, however, to be borne in mind that such replacements can only be carried out efficiently with the aid of special jigs and tools, the issue of which is confined solely to repair depôts and schools of technical training.

ROTARY ENGINES.

DAILY ROUTINE :—

17. In addition to those notes in the first part, many which are applicable alike to stationary and rotary engines, the following special points in connection with rotary engines must receive attention.

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General :

18. Examine for overheating. Look for blueing of cylinders. Note condition of valve springs and valve gear casing. Feel thrust box for excessive heat.

With paraffin and a stiff brush clean the cylinders and valve springs whilst the engine is hot. Remove rust with fine tape emery cloth, taking care that no paraffin or emery enters the cylinders.

Grease over the exterior of the engine, using engine oil and a soft brush

Note that all nuts are fast and that circlips, spring washers and other locking devices are sound and in place.

Note that rocker pins and springs stops are in order. Note that valves seat properly and that rocker arms operate freely. Oil by hand all parts not lubricated mechanically. Check over tappet clearances.

Note.—Care should be taken when adjusting valve push rods that adjustments are made when tappet in question is at the idle face of the cam, and that *before the engine is rotated* the correct clearance is present. Disregard of this precaution results in buckling of rods and straining of the rocker arm forks.

Test all controls. Note that levers are firmly held against their respective sectors in all positions. If adjustment of linkwork is necessary, the length of thread in the female of a turnbuckle must always be at least equal to the diameter of the rod.

Note that cowling is secure and correctly fitted. Clear drain holes in same if necessary. Examine side shields and note that fasteners on doors of same are secure against working open. Drain holes for petrol must be clear.

Examine tanks for leakage; rust or corrosion must receive immediate attention. Remove small spots of rust with emery cloth, tin surface thoroughly and float thinly with solder. For large patches, the tan must be replaced.

Note.—Repairs to petrol tanks must never be undertaken until the tank has been flushed out with water for some time. Pump out tank with air, and leave for some hours to permit fumes to evaporate.

When not in use, always keep engine covered with sheet of waterproof fabric.

Lubrication :

19. Fill oil tanks to within one inch of the top.

Pharmaceutical castor oil should always be used.

In cold weather it is necessary to drain the lubrication system before putting away aircraft for the night. Be sure that all oil is drained out of the pump by removing drain plug of same.

When refilling, oil must be warmed to a temperature of at least 50° C. by standing the tin in boiling water, and top plug of pump must be removed until oil issues freely.

In the case of new engines, or engines returned from overhaul or store, one or two syringesful of oil must be injected into the crankcase, either by way of rear end of the crankshaft or through the nosepiece plug. Turn the engine a few revolutions by hand to distribute the lubricant. The pulsator pipe line must always be primed, care being taken that no air lock exists here.

Ignition :

20. Clean distributor face with petrol and rag; examine carbon brushes and springs.

Note that contact breaker is correct, and that rocker arm is functioning freely. Examine platinum points, and, if necessary, reset to specified gap.

Note that all high tension leads to sparking plugs are taut but not in tension. Note that switch and hand starter leads are intact.

Make sure that insulating bushes in H.T. lead clips are sound and intact.

Sparking plugs require careful attention. Alternate sets must be removed, cleaned, and, if necessary, replaced after each flight. Check gaps and set uniformly to 0·015 in. /·020 in. (except where otherwise stated).

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Carburation :

21. Make sure that all drain pipes conduct loose petrol clear of the aircraft.

Should replacement of petrol piping circuit be necessary new sections must be bent to conform with the original members. Sharp bends or traps must be avoided.

Test operation of petrol (Volplane) cock from pilot's cockpit.

Clean out petrol strainers at frequent intervals.

If petrol is pressure-fed, raise pressure to working value, and note that it does not drop lower than 2 lbs. per square inch within from five to ten minutes.

Starting-up :

22. Test operation of engine controls and switches and set petrol cock to full-on position. In pressure-fed systems, raise pressure to working value by hand pump.

Having injected one syringeful of oil into the crankcase, pull the engine round two or three revolutions by hand to distribute it.

The fine adjustment must only be opened when sucking in is actually being performed, or when engine is running.

Having carried out instructions in previous paragraph, starting-up is performed as follows with the undermentioned carburettors. In all cases where petrol is pressure-fed, air pressure must be raised by hand pump, and relief valve adjusted to function at correct pressure.

Block Tube Carburettor.—Open throttle about a quarter, and Tampier fine adjustment valve half to three-quarters.

Turn petrol on.

Count seven seconds and turn off petrol.

With switches still "OFF," turn airscrew nine or ten times.

With switches on "CONTACT," swing airscrew and start.

Immediately start is made, adjust jet setting, keeping engine at not more than half speed for first minute of running.

Failure to start is more likely to arise owing to an excess of petrol than otherwise, and choking will invariably result if the petrol is left on until it issues from the carburettor drain pipe. If this is suspected, with switch off and throttle wide open, turn the engine backwards a few revolutions

Monosoupape.—Gravity-fed fuel system. Priming is unnecessary.

Set all switches to "OFF."

Turn engine until one cylinder is at bottom with the valve open.

Turn on petrol until it issues from open valve, then turn off.

Turn engine round twice.

With "CONTACT," open petrol regulating valve slightly, and swing airscrew, when engine should start.

Petrol Pump Fuel System.—If auxiliary starting device is not fitted.

Prime cylinders through valves.

With "CONTACT," swing airscrew, and when engine fires, open petrol valve and start.

If priming device is fitted, hand-priming will be unnecessary; instead, give two or three strokes of the hand pump and start up as above.

Pressure-fed Fuel System.—

Set all switches "OFF."

Raise pressure to 4 lbs. per square inch by hand pump.

Open petrol valve slightly to prime engine, and turn airscrew a few times.

With "CONTACT," swing airscrew, when engine should start.

Regulate petrol supply by adjusting petrol valve.

Inability to start may be due to choking of engine owing to excess petrol, which condition can be detected by leakage of petrol through the exhaust valves. Should this condition arise, it can be remedied by turning the engine a few revolutions in reverse direction with petrol cock closed and switches off.

With the Tampier petrol control valve fitted in later Monosoupape installations, it should be noted that petrol can only be completely shut off by closing the main petrol valve.

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Having started the engine, run for one minute at about half speed to warm up. When attempting to start, should a cylinder burst into flame, turn that one to top dead centre. This prevents flame spreading to crankcase.

While running to warm up, examine for oil and petrol leaks, and note pulsations of oil in the pulsator glass.

Test running of each magneto separately.

Open to full throttle, and run at full speed for only such time as it takes the tachometer needle to give a steady reading. Any tendency to exceed the maximum permissible R.P.M. indicates that an unsuitable airscrew is fitted, and this must be changed. The engine must not be kept running on the ground longer than two minutes in summer or three minutes in winter under any circumstances.

Note also that :—

(*a*) Revolutions are satisfactory and maintained.
(*b*) Engine is free from excessive vibration and is firing regularly.
(*c*) Throttle control has full range.
(*d*) Pulsator and pressure gauge readings are satisfactory.

The amount of petrol used must be kept down to the minimum, or blueing of cylinders will result.

In manipulating the controls, always lead with the throttle, and move up the fine adjustment only as far as it is necessary to develop the highest R.P.M. for the given throttle opening.

To stop engine, turn off petrol, switch off and close throttle slowly.

When running light, or taxi-ing, control as far as possible by throttle and *not* by switch. Regulate fine adjustment so that mixture is just strong enough for firing. With a Monosoupape there should be only sufficient petrol passing to maintain intermittent firing.

Never use the button switch when starting up.

In Flight :

23. Note that :—

Lubrication is satisfactory. Regular action of the pulsator indicates this.

Engine revolutions are satisfactory and maintained. (Never exceed the normal full speed R.P.M. except for short intervals.)

Every half hour or so switch off one ignition unit at a time for a few seconds in order to check the running on each set.

Range of fine adjustment of petrol valve must be adequate to weaken the mixture at all altitudes. Amount of petrol used should be reduced the minimum consistent with regular firing, and then should be advanced very slightly, thereby ensuring the most satisfactory mixture. Mixture must be neither too weak nor too rich.

The fine adjustment or petrol valve must be regulated as indicated necessary by the engine.

When descending from high altitudes with the engine off, leave the throttle fully open, turn off the Vo.plane petrol cock there by shutting off the fuel supply, and keep all switches on. *Never* switch off, or plugs will become sooty. Remember that a fresh setting of the carburettor will be necessary for the lower altitude.

INSPECTION.

24. Periodical y examine the fixings of centra. and rear supports.

Examine airscrew boss for shrinkage, and airscrew for true alignment and pitch.

Dismantle, clean and replace all oil pump and carburettor gauzes. Remember when assembling the former, to prime the system throughout with a syringe and lubricant.

Examine, oil, and adjust all joints, links, pivots and bell cranks or control rods.

Lubricate magneto bearings with a small quantity of thin oil.

Check timing of valves and magnetos with protractor provided. Check magnetos with lamp and battery test for synchronism.

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Examine distributor face, noting that segments are flush with insulator. Examine brush and holder in central support.

Overhaul.

25. Overhauls of rotary engines are classified A, B and C :—

A and B Class overhauls are undertaken by Units.

C Class overhauls are only to be undertaken by repair depôts and schools of technical training.

Top overhauls of rotary engines (except Mono) are necessary after about 50 hours' running and complete overhauls after 100 hours. For the Mono these figures are 20 and 40 hours respectively.

These times should be considered normally as a maximum, and not as a hard and fast rule. The running and behaviour of the engine may necessitate overhaul before times stated.

A.—Top Overhaul with Replacements where necessary.

This comprises the following operations :—

(i) Removal and examination of cam box and all tappet rods.

(ii) Removal and examination of connecting rods pistons and piston rings.

(iii) (*a*) Removal of crankcase and internal examination of cylinders in situ when fitted to a "two-piece" crankcase (*e.g.*, Mono).

(*b*) Removal and examination of cylinders when fitted to a "single-piece" crankcase (*e.g.*, B.R.II.). Examination of valve rockers.

(iv) Examination as far as possible of thrust bearings.

(v) Removal, examination and cleaning of magnetos, carburettors, oil pump, air pressure pump, distributor brushes and H.T. leads.

(vi) Removal, cleaning and examination and testing of all sparking plugs and plug H.T. leads.

B.—Complete Overhaul with Necessary Replacements.

This term applies only to rotary engines overhauled by Units other than repair depôts or schools of technical training. The engine is to be completely dismantled and cleaned, necessary replacements being effected.

C.—Complete Overhaul and Repair by Depôts.

This comprises all the work included under definitions "A" and "B," with the following additional operations :—

(i) All parts are completely dismantled and thoroughly examined.

(ii) All parts are inspected and conditioned under one of the three following headings :—

(*a*) Serviceable.
(*b*) Reparable.
(*c*) Unserviceable.

CLEANING SPARKING PLUGS.

26. The useful life of plugs may be considerably lengthened by properly carried out processes of cleaning. Owing to the great differences between various engines and plugs, it is impossible to lay down any hard and fast rules as to frequency of cleaning and only experience can dictate how often cleaning will be required and what length of life of plugs may be expected in any particular case.

27. Where the engines are oily, the plugs will require daily washing and more thorough cleaning every twenty hours or so. In a very clean engine, habitually run on a moderately weak mixture, it is possible that the plugs may require no real cleaning over much longer periods, although

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they must be inspected at regular intervals and should be occasionally washed before replacement. It frequently happens that plugs which remain quite clean in flight become fouled up just in the last few minutes of running, while landing and taxi-ing in at low power. It is, then, desirable to remove the plugs while still hot, and to put them to soak before the fouling has time to dry and harden.

28. Non-detachable plugs can only be cleaned by soaking for some hours in spirit to loosen the fouling, and using a stiff bristle brush to remove the deposit as completely as possible from the mica and the body. Plugs which have been used in engines run with mineral lubricating oil should be soaked in petrol, or in benzole if obtainable; plugs fouled with castor oil should be soaked in alcohol (methylated spirit) instead of petrol.

29. Detachable insulators should be loosened in the plug bodies before being put in soak as above. After soaking the deposit can be remove from the metal parts with a wire brush or scraper, care being taken not to damage the thread, the earthed electrode, or the copper-asbestos jointing washer between the insulator and the body. The mica insulator must on no account be scraped with anything hard or with a wire brush; a stiff bristle brush, such as a nail brush, can be used to remove deposit. A piece of very fine glasspaper may be used to polish up the surface of the mica, and, if possible, the insulator should be chucked in a lathe by the brass hexagon nut for this process. A final polish can be given by a soft rag or a piece of wash leather, or better still by a calico polishing mop kept for this purpose only. It is of the utmost importance that the cleaning materials be free from particles of metal or grit, and any brushes or other gear should be kept for this special purpose alone.

30. Each detachable insulator must be replaced in its original steel body, otherwise there is a great probability of the plug being leaky. The insulator should be screwed up moderately tight on its copper-asbestos washer, but it is not necessary to apply great force; a good-fitting box spanner, and a tommy bar about ten inches long should be used. After assembly, the spark gap must be examined and adjusted by bending the earthed electrode, not the insulated centre one. The correct gap for plugs used in all stationary and radial engines is 0·015 in. (15-thousandths); and for rotary engines 0·018 in. (18-thousandths). There should be no difficulty in setting the gaps to within two-thousandths of the correct distance, and it is better for them to be under rather than over the nominal width. Any sharp or ragged edges on either electrode must be removed, and this is better done before assembly. These remarks apply equally to the non-detachable types of plug.

31. Finally each plug should be tested by being screwed into a pressure "bomb" or tester, when it should spark properly under an air pressure of 80 lbs. per square inch on the gauge, current being supplied by a good hand starter or other magneto.

No attempt to tighten up the small external nut clamping up the mica is permitted; in some plugs this nut is pegged, and in any case it would result only in mining the insulator. If the mica washers have obviously shfted, so that the insulator is distorted, it must be condemned right away.

When fixing and removing plugs a suitable box spanner should be used, and care taken that it is not pulled over against the insulator or the latter may be damaged.

The institution of a regular routine for the care and cleaning of sparking plugs, a careful mechanic being made responsible, will effect considerable economy in consumption and result in fewer troubles in service.

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30. ENGINE DATA.

Dimensions and direction of Rotation.

Engine.	Cylinders and Pistons.				*Crank rotates.	Airscrew.		Carburettor.	Revolution Counter Rotates.†
	No.	Bore.	Stroke.	Compression Ratio.		Rotates	Speed.		
Falcon III. -	12	4″ (101·6 m/m)	5¾″ (146 m/m)	5·3 to 1	R.H. Tractor L.H. ,,	As engine.	1,180	4 R.R.C.H. - -	Clockwise
Eagle VIII.	12	4½″ (114·29 m/m)	6½″ (165 m/m)	4 to 9	,, ,,	,,	1,080	,, - -	,,
Liberty -	12	5″ (127 m/m)	7″ (177·8 m/m)	5·3 to 1	R.H. Tractor	,,	Engine speed.	2 Duplex H.C.7, C.H. or 52 D.F. Zenith.	,,
Lion 2 -	12	5½″ (139·69 m/m)	5½″ (130·17 m/m)	5·8 to 1	,, ,,	Anti-clockwise	1,318	Napier C.H., one single and one dual.	,,
R.R.2 -	9	5·51 (140 m/m)	7·09″ (180 m/m)	5·26 to 1	,, ,,	As engine.	Engine speed.	Bloctube - -	Anti-clockwise.
Monosoupape	9	4·33″ (110 m/m)	5·90″ (150 m/m)	—	,, ,,	,,	,,	Petrol pressure fed through crankshaft.	

* Viewed from rear end (*i.e.*, opposite end to the air screw). † Facing driving shaft.

Note.—An R.H. Tractor rotates clockwise viewed from rear end. An L.H. Tractor rotates anti-clockwise viewed from rear end.

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Power and Consumptions.

Engine.	Normal		Max. Revs.	Fuel.		Oil.				Total Weight Fuel and Oil per hour.
	B.H.P.	Revs.		Cons. per hour.	Cons. per B.H.P. hr.	Brand.	Pressure.	Cons. per hour.	Cons. per B.H.P. hr.	
					Pints.		Lbs.		Pints.	Lbs.
Falcon III. -	264	2,000	2,200	147·8 pts. (133 lbs.)	·56	Castor	Main 25 Aux. 3·5	6·6 pts. (7·4 lbs.)	·025	140·4
Eagle VIII. -	354	1,800	1,900	198 pts. (178 lbs.)	·56	,,	25	8·75 pts. (9·35 lbs.)	·023	187·35
Liberty -	405	1,650	1,750	215 pts. (193 lbs.)	·53	Mineral	25–35	14 pts. (16·8 lbs.)	·03	210
Lion 2 - -	470	2,000	2,200	245 pts. (220 lbs.)	·52	Castor	45–65	11·74 pts. (14·1 obs.)	·025	234
B.R.2 - -	230	1,300	1,350	138 pts. (124 lbs.)	·6	,,	—	18–20 pts. (20–25 lbs.)	·078	144·2
Monosoupape	113	1,250	1,300	89–8 pts. (80·8 lbs.)	·795	,,	—	15·6 pts. (17·5 lbs.)	·138	98·3

Note.—Engines use Castor pure in summer, and Castor treated in winter. Engines use Mineral thick in summer, and Mineral thin in winter.

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Ignition and Timing.

Engine.	Magneto.				Sparking Plugs.	Inlet.			Exhaust.		
	No.	Type.	Speed.	Timing.		Opens.	Closes.	Tappet Clearance (Cold).	Opens.	Closes.	Tappet Clearance (Cold).
Falcon III. -	2	Watford	1.5 E.S.	Adv. 33/35° early	K.L.G. F.12	10° after T.D.C.	54° after B.D.C.	.020″	58° before B.D.C.	10° after T.D.C.	.030″
Eagle VIII.-	4	,, 2 R.H. 2 L.H.	,,	,, ,,	,,	,,	,,	.020″	,,	,,	.030″
Liberty -	–	Delco Ignition Set.	—	Adv. 30° early, Ret. 10° late.	,,	,,	45° after B.D.C.	.015″	50° before B.D.C.	,,	.020″
Lion 2 -	2	B.T.H. AV. 12s.	1.5 E.S.	Fully adv. :— 40° early on exhaust side. 45° early on inlet side.	K.L.G. F.15	,,	51½° after B.D.C.	.020″	48° before B.D.C.	10° 44′ after B.D.C.	.020″
B.R.2 -	2	P.L.R.	2¼ engine.	20/26° early (23° desired).	K.L.G. F.9	0° before T.D.C. ± 0.5°	58° after B.D.C. ± 0.5°	—	72° before B.D.C. ±0.5°	10° after T.D.C. ± 0.5°	—
Monosoupape	–	P.L.R. (R.H.)	,,	20° early - -	,,	Valve opens 90° after T.D.C., and closes 45° before B.D.C.					

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31. SPECIAL ENGINE NOTES.

FALCON III.

Components Issued with Engine from Store.

2 Magnetos.	1 Priming Device.
4 Carburettors.	1 Coil ⅜ in. Piping.
1 Airscrew Boss.	24 Sparking Plugs.

An engine of this type need not necessarily be issued with the priming device and piping when going for, or after, repair. Exhaust manifolds are not required; no hand starting gear fitted.

SPECIAL NOTES.

Lubrication :

1. Amount of oil in engine and piping is approximately two gallons, one gallon of which drains into sump when engine is stopped. After running, the oil tank should not be refilled to its utmost capacity, allowance being made for one gallon, which will be pumped from sump when engine is started up.

Oil is circulated by two pumps. The larger is the "scavenger" pump, drawing oil from sump and delivering to tank or cooler, and the smaller is the "pressure" pump, drawing from tank and delivering to engine.

Oil pressure is marked on engine plate, and is from 35 to 45 lbs. per square inch. Minimum safe, 25 lbs.

Oil pressure may fail owing to :—

(*a*) Insufficient oil.
(*b*) Air leaks on suction side of pressure pump.
(*c*) Leaks in system.
(*d*) Pressure pump filter may require cleaning.
(*e*) Oil temperature too high.
(*f*) Relief valves or seating require cleaning.
(*g*) Oil pump may require priming.
(*h*) Oil pump drive may be at fault.

Over oiling may be due to :—

(*a*) Choked oil sump filter.
(*b*) Scavenger pump at fault or requires priming.
(*c*) Air leaks.
(*d*) Restriction in delivery pipe to tank.
(*e*) Angle of inclination of engine over 16°.

Ignition :

2. Two magnetos are fitted, one R.H., and one L.H.

Ignition diagrams for R.H. and L.H. tractors are given at Figs. 96 and 97.

The low tension contracts of the magneto should be just separating when the crankpin of the firing cylinder is 33° to 35° before top centre when advanced or 13° to 15° when retarded.

In order to reset the ignition, remove inspection plug in camshaft casing, uncovering a disc which indicates which of the cylinders is on its firing stroke. Then remove inspection cover on reduction gear which is on the same side of the engine. This uncovers a pointer and letters "M.A." signifying "Magneto advance," and "M.R." signifying "Magneto retard," will be observed marked on the gear annulus.

Set crankshaft to M.A. position, turn armature of magneto until high tension brush is on the segment corresponding with the cylinder which is on the firing stroke, the control lever being in the fully advanced position. Set magneto with low tension contacts just breaking and mesh. Fine adjustment can be made by serrations on drive shaft and by magneto driving drum. This latter has 25 teeth, whilst there are 24 serrations, and adjustments can be made to .5°.

If ignition trouble is suspected, a new set of plugs should be fitted.

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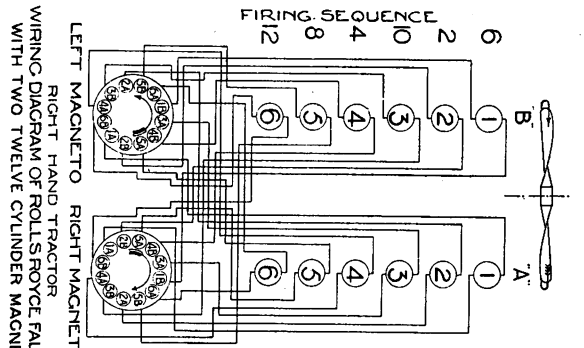
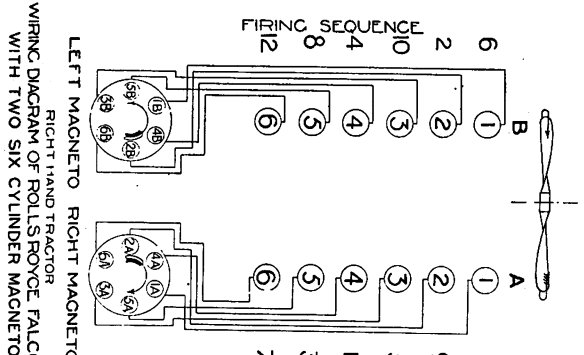


WIRING DIAGRAM OF ROLLS ROYCE FALCON III WITH TWO TWELVE CYLINDER MAGNETOS

Fig. 96.



WIRING DIAGRAM OF ROLLS ROYCE FALCON III WITH TWO SIX CYLINDER MAGNETOS

Fig. 97.

Carburation.

3. The R.R.C.H. carburettors fitted have an adjustable needle valve jet. The makers' setting is indicated by an "O" on lever and sleeve. Each division represents a 6 per cent. increase or decrease of petrol.

Suitably adjusted Falcon engines should run down to 400 R.P.M. without misfiring.

INSPECTION.

After Flight.

4. Immediately after flight an inspection should be made, and the following points observed :—

(i) That the temperatures of both oil and water are normal.
(ii) That oil and water circulation have been correct.

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(iii) That no local overheating is present. Reduction gear, thrust housing etc., should be felt with the hand.
(iv) That there are no water, oil or petrol leaks.
(v) That, when turned by hand, engine feels free.
(vi) That oil, petrol and water consumptions are normal.
(vii) Should it be probable that the engine will be exposed to frost, the water and oil systems must be drained.

After 30 Hours' Running :

5. (i) Clean out oil system, and refill with fresh oil. (ii) Inspect cylinder lubrication, also that of camshafts, timing gear, reduction gear, etc. (iii) Clean out petrol and pressure feed systems. (iv) Drain cooling system and refill. (v) Dismantle and clean oil sump filter.

OVERHAUL.

Sequence of Dismantling :

6. Below is given the order in which the operations should take place, together with notes on any particular operation for which special tools or methods are required. A curved drift—not supplied in the tool-kit—is necessary for knocking out the anchor pins of the rocker-fulcrum pins.

Note.—Whilst the sequence of dismantling is in the main the inverse of the order of erection, the handbook should be consulted when possible before attempting either.

(1) Remove all oil and water pipes.
(2) Remove all high-tension cables.
(3) Remove all magneto and carburettor controls.
(4) Remove the carburettors.
(5) Remove the magnetos.
(6) Undo the union nuts connecting the upper ends of the inclined drive shafts to the camshaft casing.
(7) Undo the nuts securing the camshaft casings, and remove the camshaft casings.
(8) Remove the cylinders.
(9) Remove the pistons.
(i) Undo the lock nuts of the locking plates.
(ii) Remove the locking plates.
(iii) Knock out the gudgeon pins from the locking plate ends, using the drift supplied. Whilst carrying out this operation, the piston should be steadied by a second mechanic, to avoid damaging the cheeks of the small end bearings.
(10) Dismantle the epicyclic gear.
(i) Remove the airscrew hub.
(ii) Remove the end plate of the thrust housing.
(iii) Remove the airscrew shaft nut.
(iv) Place the special extractor tool over the end of the airscrew shaft, and screw the nut right home over the end.
(v) Screw the ring nut into the mouth of the thrust housing.
(vi) Remove the nuts from the bolts securing the rear half of the gear case to the crankcase, or, in the case of the new type gear, from the joint securing the forward half of the casing.
(vii) With a suitable tommy bar, unscrew the nut at the end forward of the extractor tool, and withdraw the gear case and thrust housing from the air screw shaft.
(viii) Remove the casing clear of the engine, and remove the tool
(ix) In the new type gear remove the friction rings, and then the rear half of the gear case.
(x) Remove the sunwheel carrier retaining nut.
(xi) Screw the extension on the the end of the extractor.
(xii) Place the tool over the end of the air screw shaft and screw its nut home over the end of that number.
(xiii) Screw the body of the extractor over the shank of the inner race of the sunwheel carrier bearing.
(xiv) With a suitable tommy bar, unscrew the extractor nut and withdraw the sunwheel carrier bearing.

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(xv) Remove the extractor and bearing, and remove carrier retaining nut.

(11) Remove wheel case.
(12) Split the crankcase.
(13) Lift out crankshaft.
(14) Dismantle connecting rods.

EAGLE VIII.

Components Issued with Engine from Store.

4 Carburettors.	1 Priming Device.
4 Magnetos.	1 Coil $\frac{5}{16}$ in. Piping.
1 Airscrew Boss.	24 Sparking Plugs.

An engine of this type need not necessarily be issued with the priming device or piping when going for, or after, repair. Exhaust manifolds are not required; hand starting gear fitted, but no handle issued except when asked for on allotment.

Special Notes.

1. In the main, this engine may be regarded as a larger edition of Falcon III., and the notes given on that engine apply except where otherwise stated.

Lubrication :

2. *See* notes on Falcon III.

Ignition :

3. Four magnetos are fitted, 2 R.H. and 2 L.H.
Ignition diagrams for R.H. and L.H. tractors are given at Figs. 98 and 99.
For further notes *see* Falcon III.

Carburation :

4. The R.R.C.H. carburettors fitted have an adjustable needle valve jet.
The makers' setting is indicated by an " O " on lever and sleeve. Each division represents a 3 per cent. increase or decrease of petrol.
Suitably adjusted, Eagle engines should run down to 450 R.P.M. without misfiring.

Inspection.

5. Refer to notes on Falcon III.

LIBERTY.

Components issued with Engine from Store.

1 Ammeter.	1 Generator.
1 Electric Battery.	2 Distributors.
1 Lukenheimer Priming Pumpor "Roper" Spray.	1 Airscrew Boss.
	24 Sparking Plugs.

The carburettor controls must be complete from the carburettor to the horizontal bracket on the camshaft diagonal shaft covers.

Special Notes.

Lubrication :

1. This engine is fitted with a triple pinion double scavenger pump and a single pressure pump, both of which are housed in one unit which also incorporates a relief valve and which is located at the bottom of the sump at the rear end. A filter is fitted for each pump.
Oil is fed under pressure to the crankshaft and the big ends of the connecting rods and the camshaft.
The thrust bearing is lubricated by an external oil box, which must be filled up before each flight.

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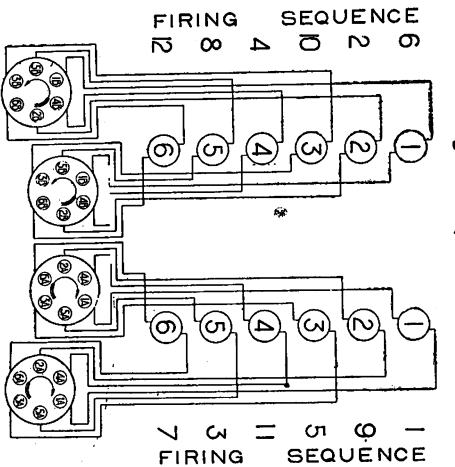

Fig. 98.

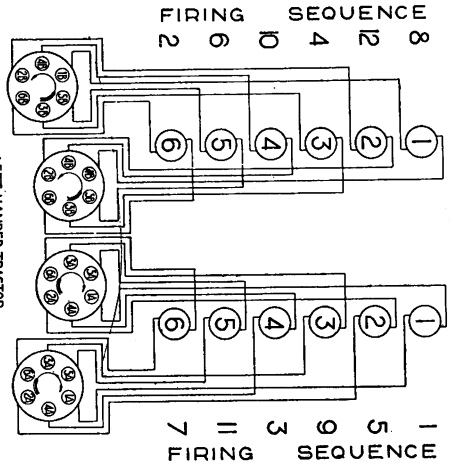

Fig. 99.

WIRING DIAGRAM OF ROLLS ROYCE ENGINE EAGLE VIII (R.H.T. & L.H.T.)

The normal oil pressure is 25 lbs. to 30 lbs. per square inch. If the pressure registers over 55 lbs. per square inch, the relief valve is probably out of order, and the fault must be remedied or a burst pipe may result.

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The oil pressure varies with the engine speed, and will always drop at low speeds if the system is functioning correctly.

About 1 gallon of oil will drain back to the sump after the engine is stopped, and this quantity should be allowed for when filling up the tank.

Ignition :

2. The ignition system is of the battery and coil type, the 8-volt accumulator being kept charged by a generator on the engine.

The battery is actually only used for obtaining the initial spark at starting, for running at low speed before the generator takes up the load, or as a stand by in the event of generator failure. The generator takes up the load as soon as the engine attains about 650 R.P.M.

There are two ignition units, one of which is mounted at the rear end of each camshaft casing. Each unit is complete with coil, contact maker and 12-cylinder distributor, and each serves one of the two plugs in each cylinder, the left hand unit firing the forward set, and the right hand the rear set. Separate control of each unit is provided by the two switches on the switchboard.

The most likely cause of trouble will be found to be the sparking plugs; these must be examined and cleaned at very frequent intervals. When testing one unit at a time to find which set contains the faulty plug it must be remembered that the fact of one switch being off disconnects the battery from the generator, and the ignition current is, therefore, being supplied by the battery. The duration of such tests should, therefore, be limited. (*See* wiring diagram at Fig. 100.)

INSPECTION.

Daily Routine :

3. Battery voltage should be tested; on open circuit (*i.e.*, both switches off), this should not be less than 8 volts. With one switch on and a discharge of from 4 to 5 amperes reading should not be less than 7½ volts.

Before starting up, switch on each system separately, and note that the ammeter readings are approximately equal. Any inequality indicates a partial short circuit in the system. Examine distributor track for cracks. A crack *opposite* to the contact terminals is not so likely to cause trouble as one *between* the segments; the latter may fill up with carbon and eventually cause a short circuit.

Make sure that both switches are OFF when engine is not running.

Weekly Routine :

4. (i) Flush accumulator (as described in handbook), and, if necessary, correct the acid density. Wipe exterior and clean from acid, and smear terminals lightly with vaseline. (ii) Remove dust from generator commutator, inspect brushes and sparingly oil ball bearing at top of armature spindle. (iii) Clean out contact breaker and sparingly oil pivots. (iv) Clean and inspect voltage regulator. Check (and reset if necessary) gap. Correct gap ·005 in. / ·007 in. with blade against stop pin. Sparingly oil pivot bearing.

Monthly Routine :

5. In addition to above attentions :—

Open up switch. Clean all contacts and smear track slightly with vaseline. Inspect resistance. Check timing and synchronism of contact breakers. Fit new distributor brushes.

Timing the Ignition :

6. The two ignition units are timed alike, and must be in synchronism. With both units dismounted from the camshafts :—

(i) Set both units to fully retarded position.

(ii) Turn crankshaft until No. 1 cylinder is 10° A.T.D.C. down *firing stroke* (*i.e.*, both valves closed). The spring blade, or dowel (whichever is fitted) of the coupling will now be aligned with the centre line of the cylinder block concerned.

(iii) Turn the distributor brush holder to contact with No. 1 segment. Holding the brush in this position, mount unit on end of camshaft;

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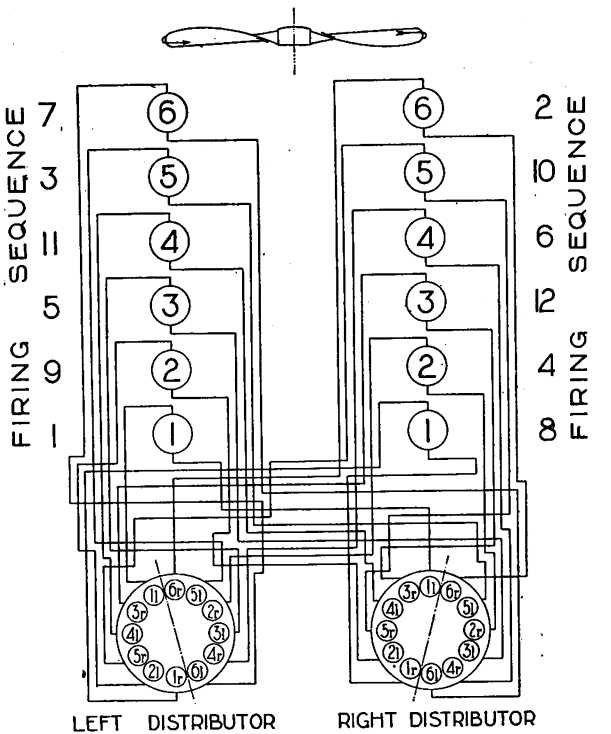
with the brush in this position it will be found that the members of the coupling will mesh.



WIRING DIAGRAM OF LIBERTY ENCINE

FIG. 100.

(iv) Loosely bolt the flange of the unit to that on the camshaft, screwing the nuts up finger tight.

(v) When the other unit has been similarly mounted, final adjustment is made as follows :—With control levers fully retarded, and crankshaft still at same position on *firing stroke* (10° A.T.D.C.), move the unit round until points of main contact breakers are just breaking. When this setting is determined, tighten up the six bolts.

Check by lamp and battery test; if O.K., mark flanges of units and casings for future reference.

The correct setting for contact breaker gaps is ·012 in. at full lift.

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RUNNING NOTES.

7. These notes are to be considered as additional to those in the foregoing general notes.

Before Flight :

8. With a new engine, or one from store : Pour about ½ gallon of oil into sump to prime pumps. Lubricate the generator driving shaft by the oil cap provided.

Starting Up :

9. (i) Retard ignition and open throttle about one quarter. (ii) With switch OFF, prime with priming pump, turning the airscrew meanwhile. Three to four pumps full will be sufficient. Continue to turn engine for two revolutions after priming. (iii) Leave airscrew with contact points just open. This point should be determined and marked on the cowl and airscrew respectively. (iv) Call "Stand clear." Switch on *right hand switch only*, and press starting buzzer button. (If the above instruction is disregarded by switching on both switches, the battery will discharge through the generator). (v) If necessary to swing airscrew (or rotate turning gear) buzzer may still be used with safety, as it is inoperative until main contact points are separated.

N.B.—In handling this engine, particular care is necessary with the switches, as with this system the mere action of switching off and on may cause the engine to fire. Therefore keep all clear of airscrew when these are being manipulated. As soon as the engine fires, advance spark about half-way.

Warm up for about three-quarters of a minute to a minute and a half (according to weather). Then open up to 600 R.P.M., and switch on second switch. Set the throttle until ammeter reads zero, and run at this speed until engine is thoroughly warm. Leave radiator shutters slightly open, or else water temperature will rise too quickly in proportion to oil.

Advance ignition fully before opening to full throttle.

INSPECTION.

After Flight :

10. (i) Inject small quantity of paraffin into cylinders by cocks and turn airscrew one or two revolutions by hand. (ii) Fill up thrust bearing with oil. (iii) Clean petrol filter and, if required, oil filters. (iv) Particular attention must be given to ignition system as outlined in the special instructions issued. Examine accumulator and test firing in each distributor. (v) Occasionally examine condition of water pump stuffing gland, and note that no overheating takes place here.

OVERHAUL.

Sequence of Dismantling :

11. *Note.*—Whilst the sequence of dismantling is in the main the inverse of the order of erection, the handbook should be consulted when possible before attempting either.

(1) Airscrew hub.
(2) High tension cables and carrier. Ignition units. Generator sparking plugs.
(3) Carburettor.
(4) Water elbows and induction manifolds.
(5) Camshafts, with upper inclined shafts.
(6) Lower inclined shafts.
(7) Generator shaft.
(8) Oil pump unit.
(9) Water pump and lower vertical shaft.
(10) Cylinders.
(11) Pistons.
(12) Lower half of base chamber.
(13) Connecting rods.
(14) Crankshaft.

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LION SERIES II.

Components issued with Engine from Store.

24 Sparking Plugs.	1 Oil Filter.
2 Magnetos.	1 Priming Pump.
2 Carburettors.	

Engine fitted with hand starting gear, and coil of Bowden Wire for distant operation of clutch throw-out gear.

SPECIAL NOTES.

Lubrication :

1. There are two scavenger pumps, each of which withdraws the oil by a separate pipe from opposite ends of the sump. As the capacity of each scavenger pump is greater than that of the pressure pump, it follows that the scavenging arrangements are not greatly affected by level within reasonable limits.

No filters are fitted in the engine, the gauze through which the oil is filtered being a separate unit housed in a vertical chamber which is inserted in the return pipeline from the scavenger pumps to the supply tank. This filter must be periodically inspected and cleaned.

In installation, particular attention must be paid to the relative position of the filter chamber to the tank.

Oil pressure is 50 lbs. to 65 lbs. per square inch; the minimum safe pressure is 45 lbs. per square inch.

Frequent inspection should be made for leaks, cracks, etc. in the external pipework on the engine.

Apart from general causes, such as wear in the bearings concerned, loss of pressure in the lubrication system may possibly be attributable to the relief valve. If this source is suspected, the valve should be removed bodily with its casing to avoid disturbing the adjustment before examination for foreign matter round the seating has been made.

In the earlier engines the conical head of the valve was set clear of its seating, thereby constituting a permanent leak. In later engines the lip on the body which held the valve off the seating is removed. Consequently, the latter type is more liable to retain any foreign matter between the head and the seat.

The adjustment of the valve should not be disturbed until it is proved beyond doubt that the cause of the trouble lies here, as this is very carefully set by the makers.

Ignition :

2. Two 12-cylinder magnetos are fitted; both run anti-clockwise (L.H.), and both are provided with terminal and trailing electrode for connection of the cable from a hand starter magneto. Wiring diagram giving the firing order will be found on a plate on the top of the centre block of cylinders.

Particular care must be taken in connection with the H.T. leads. These are metal braided, and the presence of this covering has a tendency to cause induced currents to be set up which might result in sparking taking place whenever the covering approaches "earth." To obviate this sparking, the cables are connected to "earth" at frequent intervals throughout their length.

The connections at each end of the H.T. cables require very careful fitting and must be dealt with in accordance with the special detailed instructions given in the hand book.

To retime the magnetos after overhaul, etc. proceed as follows :—

(i) Set the engine with one of the end pistons of the centre block (No. 5 or No. 8 cylinder) at T.D.C. This may be done by inserting a rod in the sparking plug hole.

(ii) Fit the magneto couplings and lock the spindle end nut by a split pin.

(iii) Remove the distributor and contact breaker cover, and turn spindle until the main electrode is opposite to the segment corresponding to the particular cylinder which is being timed, and hold in this position.

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(iv) Slip driving flange into coupling, leaving the bolts out, and put the magneto in position.

(v) Noting that distributor is still in same position, turn coupling until contact breaker points are open by ·001 in., and this with timing lever set at full advance. Hold contact breaker in this position.

(vi) Find which pair of bolt holes comes dead opposite, and insert the two bolts and tighten nuts finger tight.

(vii) Check by lamp and battery, connecting up so that when the contacts are closed, the lamp lights.

(viii) Turn engine backwards a little until lamp lights, then turn slowly forward until lamp goes out. This is the firing point as now set and should be T.D.C. If not T.D.C., reset vernier adjustment to make correct.

(ix) The required angle of advance on the L.H. (exhaust side) magneto is 40°, and on the R.H. (inlet side) 45°. Dealing with the L.H. magneto, since 40° is the advance on the crankshaft, the corresponding advance on the magneto drive shaft will be 60°. To effect this, mark the hole in which the bolt is in each half of the vernier coupling, count four holes clockwise (backwards) round the magneto coupling, remove the bolts, turn magneto in its running direction until bolts will enter again through the original marked holes in driving flange, and through new holes in magneto coupling flange. An advance of 60° will now have been made (four holes, 15° apart =60°) equivalent to 40° on the crankshaft. For the R.H. magneto, 67½° advance is required (equal to 45° on the crankshaft). This equals turning the magneto forward through 4½ bolt holes.

(x) Enter fixing screws into base of magneto, and by turning engine note that magneto alignment is O.K. Then tighten up fixing bolts and coupling bolts.

Carburation :

3. The magneto and throttle controls are interlinked on the Lion II engine; in adjusting the link rods care must be taken that the full range of the ignition control is obtained.

The temperature of the water circulated through the carburettor jackets may be regulated by a screw-down cock provided in the return pipe to the pump. As the flow is decreased, less hot water enters the jackets, and vice versa.

Running Notes.

4. *N.B.*—Particular attention is drawn to the instructions on the warning plate which specifies the maximum revolutions at which the engine may be run. These instructions must be closely adhered to.

Starting Up :

5. (i) Note that running and starter magneto switches are off. (ii) Set throttle approximately ¼ in. off closed stop screw on carburettor. (iii) Turn on petrol to carburettor and primer. (iv) Engage hand-turning gear by moving throw-out handle to forward position. (v) Crank turning gear vigorously, meantime operating priming pump as follows :—

2–4 pumpsful if engine is cold.
1 pumpful if engine is warm.
0–1 pumpful if engine is hot (according to atmospheric temperature).

Make suction stroke slowly and delivery stroke quickly. Prime sparingly. (vi) Turn off petrol to pump. (vii) After turning engine through 1 revolution switch on all magnetos and crank starter magneto, turning engine the while. (viii) The engine having started, switch off starter magneto and remove turning gear handle, if detachable.

N.B.—If engine refuses to start first time, do not use priming pump again until two or three further unsuccessful attempts have been made.

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INSPECTION.

After Flight :

6. Screw down grease cap on water pump two turns after each flight. Remove cam covers; check (and adjust if necessary) valve tappet clearances.

Note that gland on water pump spindle is not leaking, and locknut of same is secure.

Examine airscrew for firmness on hub and security of hub on shaft. Note that nut is tight.

OVERHAUL.

Sequence of Dismantling :

7. *Note.*—Whilst the sequence of dismantling is in the main the inverse of the order of erection, the handbook should be consulted when possible before attempting either.

(1) Remove primer pipes.
(2) Remove water intakes, decompressor rods and camshaft oil pipes.
(3) Remove water outlet pipes and pipes to carburettor jackets.
(4) Take off carburettor and link work and also return pipe from carburettor jackets.
(5) Remove high tension leads and conduits.
(6) Disconnect magneto control levers, and take off magnetos, leaving vernier adjustment undisturbed.
(7) Uncouple upper and lower shafts of camshaft drive shafts.
(8) Remove oil pipes between sump and pumps.
(9) Remove rear cover and hand turning gear as one unit.
(10) Lift off cylinder blocks.
(11) Take off pistons.
(12) (If required) remove airscrew shaft complete with front cover.
(13) Invert engine. Detach oil pipe to forward end of crankshaft and pipe to reduction gear; take off sump.
(14) Remove connecting rods.
(15) Take off crankshaft bearing caps; lift out crankshaft.

Note.—Removal or fitting of cylinder barrels from or to the head casting must only be undertaken by skilled mechanics in workshops fully equipped for the job. In service each block must be regarded as an integral unit.

Slinging the Engine :

8. *Front End.*—Pass sling around nosepiece.
Rear End.—Attach to shackles provided between two rear cylinders of centre block.

B.R. 2.

Components issued with Engine from Store.

1 Sight Feed Cpte. (Oil).	1 Oil Pump.
2 H.T. Leads.	1 Dust-Cap for Crankshaft.
1 Carburettor.	1 Centralising Flange (Rear).
2 Magnetos.	18 Sparking Plugs.
2 Carbon Brushes and Springs.	

The oil pipe from oil pump to crankshaft must be removed before despatching engine; also the Eliot gear box if fitted. Tappet rods to be disconnected.

SPECIAL NOTES.

Lubrication :

1. A Le Rhone type of oil pump is mounted on the rear face of the central support; the pump pinion is driven by the large gear wheel on the thrust box.

This pump is of the oscillating cylinder type. The delivery is adjustable by a screw on one side of the casing which regulates the pressure between the flat on the oscillating cylinder in which the port is cut, and the corresponding face on the casing against which the flat works, and in which are cut the delivery and intake holes.

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The interior of the pump casing is kept filled with oil from a gravity tank. Oil is delivered from the pump to a branch of a four-way junction piece. The remaining three branches serve :—

(*a*) The Air Pump (branch has an adjustment screw).
(*b*) The Pulsator.
(*c*) The Engine.

Oil from the last named is led along the hollow crankshaft by a copper pipe which enters the base of the crank web. A bye-pass from here lubricates the thrust box, whilst the main supply continues into the hollow crankpin. From here oil is distributed to :—

(i) The big ends of the auxiliary connecting rods via the hollow wrist pins and also by spray into slots in the big ends. Oil passes thence up the hollow rod to the gudgeon pins. A certain quantity lubricates the master big end bearings.
(ii) The cam-gears assembly via a duct in the web of the maneton.

The inlet union of the air pump is co-axial with the driving spindle; the overflow union is on the small crankcase cover.

It is vital that all ollways and ducts be perfectly clean and when crankshaft is dismantled these must be syringed out with paraffin.

Ignition :

2. Two M.L. magnetos each supply one of two separate circles of segments on the distributor disc. The right-hand magneto supplies the outer circle, and the left-hand one the inner. The magnetos which give two sparks per revolution run at 9/4 engine speed, the left-hand one serving the rear, and the forward the front sets of plugs.

The naked brass wires by which the current is carried from the distributor to the plugs must be neither too slack nor too taut.

N.B.—It is inadvisable to remount the magnetos or the pump before the crankshaft is drawn up tight into the central support, as otherwise the teeth of the large gear wheel are likely to foul those of the large driving pinions of the above units, unless great care is exercised. If it is desired to mount the engine with the magnetos in position, the former should be oscillated gently to and fro during the process in order to facilitate engagement of the gears.

Assuming that the valves are already timed :—

(i) Place No. 1 cylinder at T.D.C. *on the firing stroke.*
(ii) Using protractor turn engine clockwise (backwards) until this cylinder is 22°–24° B.T.D.C.
(iii) Turn armature of either magneto in running direction (*see* arrow) until points are just breaking, and mesh pinion with the gear-wheel on engine without disturbing setting of either wheel. Bolt magneto in position. The same applies to remaining magneto. When both are timed, check for exact synchronism of break at points.

Gap at plug points ·018 in. to ·020 in.

When fitting new carbon brush to distributor, note that tip of brush is flush with socket when spring is fully compressed.

Running Notes.

3. With a new engine, pour in half a pint of castor oil at the air intake and open throttle momentarily to allow this to be drawn in.

Change one set of plugs after each four hours' running; taking these in alternation all plugs are renewed after every eight hours' running.

Inspection.

4. *After* 20 *hours' running* :—
(i) Adjust push rods.
(ii) Clean distributor.
(iii) Clean carbon brushes.
(iv) Clean and reset sparking plugs.
(v) Examine contact breaker in magnetos.
(vi) Clean oil and petrol filters.

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OVERHAUL.

Sequence of Dismantling for Top Overhaul :

5. *Note.*—This does not involve removal from aircraft.
(1) Remove nosepiece.
(2) Free push rods from rockers.
(3) Remove cam gear box.
(4) Withdraw short end of maneton.
(5) Remove pistons and connecting rods, commencing with Nos. 5 and 6. (Special extractor for wrist pins.)
(6) Remove cylinders.

Top Overhaul :

6. The following points amongst others must receive attention :—

(i) Remove carbon from cylinders, cylinder heads and pistons. In dealing with the last-named, care must be taken not to tear or damage the soft metal.
(ii) Grind in valves only if necessary.
(iii) Lubricate rocker arms with thin oil.
(iv) Note that valves are free in their guides, and that both valves and guides are clean.
(v) Clean and reset sparking plugs. Clean distributor disc and inspect H.T. carbon brushes. Examine H.T. lead wires.

Assembling :

Sequence of assembling is the reverse of that of dismantling.
Verify valve timing and reset push rods if necessary.
Grind cylinder head to barrel with finest grinding paste, and finish off with rouge; a gastight joint here is *essential.* No jointing material is used for this joint.
The cylinder securing nuts must be screwed down absolutely *evenly.* Run them up finger tight first, then work round, giving each *half a turn* only, in rotation until tight.
The jointing material used for the inducton pipe is brown paper coated with gold size.

Adjustment of Push Rods.—Inlet valve push rods must be adjusted to give the correct opening of the valve, and exhaust rods the correct closing. Adjustments must be made in conjunction with use of the protractor. A further depression of the valve of at least $\frac{1}{2}$ mm. must be possible when at maximum lift. Grease cup in push rod end of each rocker before entering push rod. Adjustments to be made with engine cold.

Mounting Engine in Fuselage.—Note that the central support is accurately located. *Facing the front of the fuselage,* the lower keyway must be situated at bottom *dead* centre, when the upper keyway will be found to lie at approximately 11 o'clock. When mounting the engine, it is imperative that the keys on the crankshaft should be entered carefully.

Timing the Valves.—The magnetos having been previously timed :—

(1) Place No. 1 cylinder at 22°–24° before T.D.C. (by protractor) on *firing stroke.*
(2) Holding cam gear box on its edge, rotate cam gears until both tappets marked "I" are "down," *i.e.,* at bottom of their stroke.
(3) Note that keyway of crankshaft extension is at bottom, *i.e.,* 6 o'clock.
(4) Mount cam gear box with No. 1 tappets, registering with their appropriate push rods.

Sequence of Dismantling for Complete Overhaul :

(1) Remove nosepiece.
(2) Free push rods from rockers.
(3) Remove cam gear box.
(4) Withdraw maneton.
(5) Remove pistons and connecting rods, commencing with Nos. 5 and 6. (Special extractor for wrist pins.)
(6) Remove carburettor and crankshaft nuts behind rear support.
(7) Remove magnetos and pumps.

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(8) Free engine from central support.
(9) Lift engine out of aeroplane and place face downwards on a stool.
(10) Remove induction pipes and H.T. lead wires.
(11) Remove cylinders.
(12) Free crankshaft from thrust box.
(13) Support crankcase and drive out crankshaft with a soft hammer.

General :

9. *Removal of Gudgeon Pins.*—Not to be undertaken in engines not reconditioned unless necessary for replacement, etc. Special extractor provided. Piston must be heated in oil to 160° C. before removal or replacement of gudgeon pin.

Fitting Pistons in Cylinders.—When in cylinder, cut away side of piston lies on trailing side of cylinder. Beware of piston dropping beyond end of stroke and rings expanding into cylinder head; removal of head will be necessary if this occurs.

Taped Joints on Induction Pipes.—These must not be disturbed in the normal course; break the joint only when necessary for replacement, etc.

MONOSOUPAPE.

Components issued with Engine from Store.

1 double sight feed (oil).	1 dust cap.
1 magneto.	1 carbon brush and spring.
1 oil pump.	1 rear centralising flange.
1 mechanical air pump.	1 H.T. lead.

The Eliot gear box should be removed before despatch is fitted. Tappet rods to be disconnected.

SPECIAL NOTES.

General :

1. The outstanding characteristics of this engine are :—

Absence of inlet valves.
No carburettor.

Although based on the four cycle principle, the cycle of operations in this engine differs somewhat from the commonly accepted form.

There is no carburettor. Petrol is injected into the crankcase through a pipe in the hollow crankshaft. The exceedingly rich mixture so formed is admitted to the cylinders on the induction stroke by a row of holes around the base of the cylinder, which holes communicate with the crankcase. These are uncovered when the piston reaches the lowest point of its stroke. At the same time the valve, which opens very early down the stroke, is kept open for over 360°, and remains open for more than half-way down the induction stroke; this admits air into the cylinder. The valve closes at about 60° before B.D.C., but as the holes or ports are not uncovered until 20° before bottom, a slight depression is formed within the cylinder, and this has the effect of sucking in the rich gas through the holes as soon as they are uncovered. The air in the cylinder dilutes the gas, the resultant mixture being of the normal proportions of petrol and air. A normal compression and working stroke follow.

Lubrication :

2. Oil is delivered into the engine by a Gnome two-barrelled pump working on the valve and piston principle. The pump is mounted at the rear of the engine, and is driven by the large gear wheel at the back of the thrust box. The two exits from the pump are connected to two nipples on the crankshaft known as the "B" and "C" supply respectively.

The "C" supply serves :—

Thrust box
Cam sleeve
} Pressure.

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DAILY EXPRESS

Cam rollers Rocking levers Tappets Planet wheels Tappet rods Pin on tappet rod Rocking lever pin	Centrifugal.

The " B " supply serves :—

Big end bearings Wrist pins Gudgeon pins	Pressure.
Cylinder walls	Centrifugal.

Each supply has a separate sight feed or pulsator glasses.

Timing the Valve : (Without relation to the spark.)

3. The valve opens 90° down the power stroke.

(i) Turn No. 1 cylinder to 90° A.T.D.C. (Protractor.)

(ii) Turn camshaft clockwise until No. 1 cam is about to lift the valve.

(iii) Holding cam in this position, take the front plate, with satellite pinions fitted, turn pinions until the teeth marked " O " in each are diametrically opposed to each other inwards, and visible through the central aperture in the plate.

(iv) Fit front plate to valve gear case, so that gears are in mesh and the bolt holes in line. Two steel rods, pushed through the bolt holes, will assist the operation.

(v) Verify setting, checking closing point of valve. If necessary, adjust tappets to obtain the correct timing.

Timing the Ignition :

4. The spark occurs 20° before T.D.C.

(i) Set No. 1 cylinder at the above angle before T.D.C.

(ii) Turn magneto spindle in running direction until contact points are just breaking.

(iii) Holding armature at this setting, mount the magneto on the bearer plate, and secure in place with bolts.

N.B.—The setting of No. 1 cylinder at 20° B.T.D.C. may be approximated by setting No. 5 cylinder vertically downwards, when the three cylinders, Nos. 9, 1 and 5, will form respectively the arms and stem of the letter " Y."

Running Notes.

In Flight :

5. *Climbing and Turning.*—During a very steep climb of short duration, the engine may be temporarily overloaded, causing a slight drop in the R.P.M. When petrol is fed by automatic air pump, the mixture will vary slightly with the R.P.M., but readjustment of the mixture is not occasioned as the engine will recover when normal flight is resumed.

In a normal climb of long duration, mixture strength must be readjusted so that engine develops its maximum speed.

Descents.—Three methods available :—

(*a*) By switching off and on (for short duration only).

(*b*) Closing petrol regulating valve, thereby throttling the engine.

(*c*) With engine stopped—by turning off main petrol supply.

Always leave switches ON to prevent fouling of plugs with oil.

Overhaul.

Top Overhaul :

6. Particular attention must be paid to the condition of the obturator rings. These require frequent renewal. Wear will be shown at the ends of the rings. Replace rings with gap towards *leading side* of cylinder and to the front.

After overhaul, oil pump and pipe work must be primed with oil with a syringe.

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Sequence of Dismantling :

7. *Note.*—Whilst the sequence of dismantling is in the main the inverse of the order of erection, the hand book should be consulted when possible before attempting either.

(1) Remove engine from aircraft (extractor provided for crankshaft). Fix in suitable stand.
(2) Remove high tension wires and sparking plugs.
(3) Detach tappet rods and remove valves and valve cages.
(4) Remove large nut holding ball bearing in front cover, and remove bolts holding front cover on to valve gear case.
(5) Remove front cover (extractor provided), and take off crankshaft gear.
(6) The camshaft may now be dismounted.
(7) Draw off valve gear case.
(8) Draw off short end of crankshaft.
(9) Withdraw wrist pins.
(10) Withdraw all connecting rods and pistons except the master rod.
(11) Remove all except two of the nuts securing crankcase to thrust cover. Slack off the remaining two.
(12) Withdraw master rod big end cage as far as possible with dog provided.
(13) Loosen two remaining nuts and withdraw crankcase, simultaneously withdrawing master rod big end. When possible, remove latter from crankpin by turning sideways.
(14) Remove crankcase and cylinders.
(15) Remove crankshaft from rear cover.
(16) Dismantle thrust box.

POSSIBLE DEFECTS WITH PROBABLE CAUSES.

8. *Symptom.*—Regular beat or gap noticeable in the sound.

Cause.—Defective plug or broken exhaust valve rocker lever.

Symptom.—Occasional miss.

Cause.—Defective plug, wrong mixture or bad timing. Tappets may be sticking.

Symptom.—Marked irregularity of firing after running some time.

Cause.—Incorrect pressure feed. Insufficient petrol. Petrol cock has "crept" to partially closed position. Jet choked. Timing gear at fault. *Obturator rings broken.*

Symptom.—Engine starts, but R.P.M. fall off after, say, 10 minutes running. Continues to fire spasmodically when switched off.

Cause.—Overheating. Possibly excess of carbon. Overhaul required. Look for blueing.

Symptom.—Engine will not start, but fires from mixture in cylinder which is exhausting.

Cause.—Timed on wrong stroke.

Symptom.—Vibration after overhaul.

Cause.—Possibly bent crankshaft due to careless handling. Note also that crankshaft is properly secured in central support.

Symptom.—Cylinders blued for about 1 inch in one part only.

Cause.—Probably broken obturator ring.

Symptom.—Sudden crack. Engine continues to rotate, hissing, but refusing to fire.

Cause.—Broken timing wheels.

Symptom.—Engine commences to vibrate slightly. Distant hissing sound is audible.

Cause.—Broken valve guide.

General.—Close observation of the obturator rings is necessary. The life of these is comparatively short and, as seen from the above, these rings are responsible for many troubles.

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32. TABLE OF TROUBLES WITH THEIR SYMPTOMS AND CAUSES.

Difficulty in Starting.

I. Guiding Symptom.	II. General Cause.	III. List of Defects.	IV. Remedy.
I. Explosions in carburettor, ignition in order.	Weak mixture -	1. Engine not running fast enough.	—
		2. Atmospheric temperature very low. Engine very cold.	Fill up radiator with boiling water. Warm up dope-squirt before taking in petrol for injection.
		3. Petrol stale or low grade - -	Drain off and replenish.
		4. Insufficient priming - - -	*See* 2.
		5. Air leaks in induction system; leaky compression cocks, valves or plugs.	Test for air leaks. Grind in valves and compression cocks. Tighten up all bolts on joints. Tighten up plugs. Renew C.A. washer, or replace with new plugs.
		6. Petrol level too low in diffuser; damaged or sticking float needle or toggles; collar displaced.	Check level. Test needle for truth, and for free action in guide. Note that float is sound, and that toggles and lever work freely. If collar is displaced, determine petrol level and reset afresh.
		7. Air locks in petrol pipes; choked jet, pipe or filter; water in carburettor.	Drain off and examine petrol system and determine cause.
II. Carburettor floods. Flame or smoke from exhaust pipes.	Rich mixture -	8. Petrol level too high through leaky float; dirty needle valve seating; worn needle; needle sticking.	Shake float, listening for petrol inside. Replace if leaky. If new one is not available, immerse in boiling water. Where bubbles appear, stop leak with smallest amount of solder consistent. Grind in needle valve with metal polish. Clean needle or ease guide slightly.
		9. Excessive priming or hand flooding.	With throttle open, turn engine backwards half a dozen times, *not more*; or, if fitted with hand turning gear, turn in direction of rotation.

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TABLE OF TROUBLES—*continued.*

Difficulty in Starting—*continued.*

I. Guiding Symptom.	II. General Cause.	III. List of Defects.	IV. Remedy.
		10. Carburettor too hot with light spirit, and when engine has been running.	With throttle open, turn engine backwards half a dozen times, *not more*; or, if fitted with hand turning gear, turn in direction of rotation.
		11. Enlarged slow running jet - -	Replace jet with one of correct size, or if variable, adjust correctly.
		12. Diffuser or jet not properly screwed home.	Ditto.
III. Uneven resistance when engine is turned.	Compression weak in one or more cylinders.	13. Valve or valves stuck open -	Remove and clean the stems with paraffin. If stem is warped, replace valve, grinding in with grinding paste mixed with small quantity of oil.
		14. Carbon or dirt on valve face -	
		15. Tappet clearance adjusted too close.	Correct the adjustment.
		16. Valves burnt or distorted - -	Replace any valves which are badly distorted.
		17. Leaky piston rings - - -	Examine pistons for worn or displaced rings.
		18. Piston head cracked or broken -	——
		19. Leaky compression cocks - -	Grind in with metal polish, or renew.
		20. Loose or leaky sparking plugs -	Screw up and fit new C.A. washer. Replace leaky plugs.
IV. Engine does not fire at all.	No spark at plugs -	21. Switch in "Off" position -	——
		22. Switch defective - - -	Examine toggles and spring, contact fingers and terminals.
		23. Switch wire chafed through and "earthed."	Examine run of wires, terminal eyes, etc.

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		24. Contact breaker, lever bush seized on pivot; spring broken; platinum tipped screw slacked back; earthing button inside cover, spring broken or adrift; insulation of contact screw carrier block defective.	Remove lever, ease bush with special reamer; replace spring; readjust contacts to 0·010–0·012 in. gap; replace cover or spring; change contact breaker, or fit new insulation.
IV. Engine does not fire at all.	No park at plugs	25. Winding of armature or coil broken down; condenser failed; internal lead or connection broken or shortened; slip ring or H.T. pick-up faulty; distributor rotor cracked or burnt out.	Test winding for continuity by battery and galvanometer or from lighting main through a lamp; if faulty, replace by new magneto. New condenser or slip ring can be fitted only in proper repair shop.
		26. (Coil ignition only.) Accumulator run down or disconnected.	Recharge accumulator and make up electrolyte in accordance with detailed instructions on label.
V. Engine kicks backwards at starting.	Ignition - -	27. Timed too early on drive; hand control too much advanced.	Retime on drive; retard by hand control.
		28. Two or more H.T. leads crossed on plugs or distributor terminals.	Trace leads and check firing sequence.
		29. Magneto distributor gears wrongly meshed.	Remove magneto; remesh gears correctly.
		30. Wrong handed distributor rotor.	—
		31. Badly carbon-tracked distributor	Clean with petrol on rag. If burnt, clean up with fine glass paper, or if very bad, rebore in the lathe. (On no account must emery cloth or metal polish be used.) Carbon brush may be wiped clean, but the glaze should not be taken off.
		32. Distributor rotor burnt out from starter electrode to main brush.	Renew the rotor.

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TABLE OF TROUBLES—*continued.*

Difficulty in Starting—*continued.*

I. Guiding Symptom.	II. General Cause.	III. List of Defects.	IV. Remedy.
VI. Engine stops after a few revolutions.	Fires only while hand-starter magneto is in use.	Nos. 21, 22, 23, 24, 25, and 26 -	——
	Weak mixture -	Nos. 2, 3, 4, 5, 6 and 7 - - -	——
		33. Altitude control cock open or leaking.	Ensure good fitting cock.
		34. Air leak from float chamber to choke.	Trace to defective joint. Remake joint with good paper washer and goldsize. If due to faulty altitude control, clear with wire and blow through with an air pump; syringe out with petrol.
		35. Air leak pipe stopped up - -	
	Rich mixture -	Nos. 8, 10, 11 and 12.	

Irregular or Bad Running.

VII. Misfiring, knocking and explosions in carburettor and exhaust pipes.	Ignition - -	Nos. 28, 29, 30 and 31 - - - -	——
VIII. Misfiring on certain cylinders only.	Ignition - -	36. Dirty or defective plugs - -	Clean or change plugs.
		37. Plug gaps too wide or too close. (Average best setting is 0·015 in.)	Set gaps correctly.

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		38. Loose plug or distributor terminals	Check over and tighten up, but use no undue force.
		39. Insulation of H.T. leads perished particularly when fitted in metal conduit.	Examine leads for cracks and perishing; watch for sparking to "earth" while engine is running.
	Uneven compression.	Nos. 13, 14, 15, 16, 17, 18 and 20.	
	Mixture -	No. 5 - - - - - - -	—
IX. Irregular misfiring on all or any cylinders.	Ignition - -	Nos. 24, 26, 31, 36, 37, 38 and 39 -	—
		40. Distributor pick-up or carbon brushes or springs broken or missing.	Fit new brushes or springs; ensure that they are free in guides.
		41. Contact breaker lever bush partly binding on pivot, or much too loose and sloppy; gap wrongly adjusted (should be 0·010–0·012 in.).	Ease bush with special reamer, or fit new lever. Adjust gap to correct setting.
		42. Camcage or contact breaker base very loose on seating.	Ensure correct fitting, and if necessary, fit new parts, and readjust contacts as necessary.
		43 Sparking over outside of plug insulator (usually only at full load); sparking from plug or cable terminal to cowling or earth.	Check gap of plug points, which may be too wide. See that there is at least ¼-in. air gap to "earth."
		44. Distributor rotor dirty and sparking from brush to earth.	If dirt is of a metallic nature, probably due to worn gearing, clean rotor and examine gears. In some cases the gears are adjustable for mesh.
		45. Safety gap set too close (should be 7½ to 9 mm., according to type).	
X. Misfiring at low revolutions.	Weak mixture -	Nos. 1, 2, 3, 5, 6, 7, 33, 34 and 35 -	—
	Rich mixture -	Nos. 8, 10, 11 and 12 - - -	—
	Uneven compression -	Nos. 13, 14, 15, 16, 17, 18, 19 and 20 -	—
	Faulty ignition -	*See* "Misfiring," Sections VIII. and IX.	—

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TABLE OF TROUBLES—*continued.*

Irregular or Bad Running—*continued.*

I. Guiding Symptom.	II. General Cause.	III. List of Defects.	IV. Remedy.
XI. Misfiring at high revolutions.	**Weak mixture** -	Nos. 2 (corrects itself as engine warms up), 3, 5, 6, 7, 33, 34 and 35.	—
		46. Main jet partially choked -	Blow through jet or clean with petrol, never with wire. Drain off float chamber and petrol wells.
	Faulty ignition -	*See* "Misfiring" Sections VIII. and IX.	—
XII. Loss of power and reduced revolutions at full throttle (no actual misfiring).	**Weak mixture** -	Nos. 3, 5, 6, 33, 34 and 35 - -	—
		47. Air intake or pressure balance pipes shielded or cut off at wrong angle.	Cut off intake and pressure balance pipe mouths at an angle of 30° approximately to slip-stream. If either pipe mouth is shielded from the slip-stream, lengthen it or carry it clear of the obstruction.
	Rich mixture -	Nos. 8, 10, 12 and 46 - - -	
	Bad compression -	Nos. 13, 14, 15, 16, 17, 18, 19 and 20	
	Faulty ignition -	Nos. 26, 27, 36 and 37 - - -	
		48. Insufficient advance of ignition timing.	Advance more by hand control; if at limit, retime earlier on magneto coupling or driving gears.
XIII. Loss of power and reduced revolutions at full throttle. (With knocking.)	**Overheating** -	Nos. 27 and 47 - - - -	—
		49. Sparking plug electrodes overheated.	Try alternative plugs with less open "mouths," or stouter electrodes.
		50. Shortage of water - - -	—
		51. Pump not working properly; pipes or filter choked.	Examine stuffing glands. Cleanse system as per instruction.
		52. Unsuitable lubricating oil - -	—

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		53. Oil pump not working properly; pipes or filter choked. 54. Cylinders, piston or valves carbonised.	Look for oil leaks in pipe line. Especially note that no air leaks exist on suction side of pump. Note that flanged joint and washer are sound. Test pump in lathe with paraffin. With powerful syringe inject paraffin through all oilways, plugging all holes but one in turn to note that each is clear.
XIV. Vibration	(1) Warped or out of balance air screw.	Weak mixture. (*See* Section XII.)	(1) Test for alignment of blades by straightedge placed on plane, checking each blade in turn. Error not to exceed ¼ in. Test for uniformity of pitch by straightedge placed on a box on the floor near to propeller path. Lay straightedge on box and align it with angle of blade. Test two adjacent blades. If four blades, scribe line on box to locate straightedge and test two remaining blades.
	(2) Loose air screw boss.		(2) Remove air screw. Look for scoring on shaft. Having replaced air screw, tighten up securing nut and make doubly sure that locking device is secure.
	(3) Unbalanced reciprocating parts, due to incorrect assembly.		(3) Strip and reassemble according to markings in correct order.
	(4) Loose holding down bolts. or faulty engine mounting.		(4) Examine spring washers. Note that bolts are sound.
	(5) Misfiring	(*See* Sections IX., X., XI., XII.)	
	(6) Rough running, due to bad mixture and poor distribution, but no actual misfiring.		(6) Mixture a little too weak. Induction system cold.

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TABLE OF TROUBLES—*continued.*

Irregular or Bad Running—*continued.*

I. Guiding Symptom.	II. General Cause.	III. List of Defects.	IV. Remedy.
	(7) Incorrect tappet clearance.	Tappets on some cylinders adjusted too close.	(7) Set to specified clearance.
XV. Knocking -	(1) Pre-ignition -	*See* Section XIII.	
	(2) Loose or worn parts or bearings.	- - - - - - - -	(2) Replace or take up wear.
	(3) Weak mixture	*See* Section XII.	
XVI. Engine continues to fire after switching off, but fires regularly.	Ignition - -	55. Switch wire broken or adrift -	Trace wires and examine terminals etc.
		56. Contact breaker cover dropped off; earthing button spring broken; button badly worn and very dirty.	Examine, clean or replace, as required.
XVII. Engine continues to fire after switching off, but fires irregularly.	- - - -	57. As 55 or 56, but still making some connection to earth.	As above for 55 and 56.
		58. Plugs, valves, etc., overheated. (Engine soon stops.)	*See* Section XIII.
XVIII. Overheating	*See* Section XIII.		

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33. CARE OF ENGINES IN STORE.

1. Engines in store, either on stands or in aircraft, must be properly oiled in the first place, and have periodical attention to prevent deterioration.

Causes of Deterioration :

2. The chief factors are the deterioration of lubricating oils, and/or condensed water vapour inducing acidity and consequent corrosion of metal beneath the oil film.

Preventative Measures :

3. It is essential that the oils inserted in the engine before storage shall be those with the least possible tendency to develop acidity; that water vapour and condensed moisture shall be removed as far as possible; and that the film of oil shall cover the whole of the internal surfaces of the engine, with thorough and periodical replacement.

The following precautions should be taken to conserve engines to be stored for any length of time :—

Engines on Stands :

4. *Stands.*—Engines must be stored in a dry place on suitable stands, and covered with sheets which should entirely envelop the engine. The stands must be so constructed that no part of the engine rests on the floor, and also that the engine can be easily turned in accordance with paragraph 9.

The engine should be supported throughout its length, and the loading evenly distributed to prevent stressing of the crankcase.

5. *Closing of Port Openings, etc.*—All ports, unions and other openings are to be kept closed, to prevent the ingress of foreign matter, in such a manner as to ensure that the plugs or other closing appliances cannot be left in the engine when it is installed in the aircraft.

6. *Tappet Rods.*—In the case of rotary and radial engines, the tappet rods should be disconnected and secured to the engine.

7. *Internal Preservation.*—(i) All old oil and water must be drained from the engine; fresh oil must be poured into each cylinder, and squirted into the interior of the engine through the breathers, or crankshaft (in the case of rotary engines). " Oil Mineral, Thick, for Aircraft " should be used.

(ii) This oil should be free from acids, moisture, etc. It should be stored in as dry a place as possible, particular attention being paid to the cleanliness and thorough dryness of all measuring or filling cans employed in the introduction of the oil into the engine.

(iii) One pint of oil per cylinder should be injected through the sparking plug hole, or other convenient opening, with the aid of a syringe with a bent delivery pipe, so that oil is made to cover the whole of the cylinder wall, the crankshaft being frequently turned during the process to facilitate thorough distribution of the oil film over the whole surface. The mere pouring of oil through the sparking plug hole is quite inadequate.

(iv) In the case of " V " or vertical engines, filling should be done from two sides of the cylinder where possible, while for Napier " Lion " engines, the block of cylinders to be oiled should be brought into the vertical position for that purpose.

(v) Rotary engines, if stored on stands, with cylinders horizontal should be completely inverted after filling from one side, and in addition, oil should be inserted through the crankcase, preferably rear end, in order to reach the cam box, big ends, etc., since these parts are particularly liable to rusting.

Note.—A useful syringe can be adapted by fixing to a hand pressure pump a length of $\frac{1}{4}$ inch steel tubing, long enough to reach to the centre line of the cylinders and crankshaft throw, a collar being provided at the pump end to fit against the end of the crankshaft to facilitate pumping. The outlet end of the tube should be plugged and a series of small holes drilled round the circumference of the tube adjacent to the plug, so that the oil is sprayed uniformly in all directions.

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(vi) Engines in aircraft, or on removal from the test bed, which are intended to be stored, should on no account be oiled whilst hot, since the oil when injected is likely to dry up when the engines cool down. The oil left in the cylinders after running is insufficient for storage purposes, and must be replaced as above.

(vii) If the oil on which an engine has been run is not of the approved type indicated, it must be thoroughly drained out and replaced by the heavy oil. An efficient method of introducing this oil is to run up the engine on the test bed after it has been allowed to cool down, with the oil suction pump attached to an auxiliary tank supplying the approved heavy oil. The engine is then run for not more than three to five minutes at the minimum speed to ensure thorough distribution of the oil, without dissipation of any appreciable heat to the cylinder walls.

(viii) All camshaft covers should be removed for drying and for the thorough covering of the camshafts themselves with the above specified oil. The running of the engine, as already referred to, at low speed is insufficient to lubricate thoroughly these camshafts, and this further precaution is, therefore, necessary.

(ix) It is to be noted that before an engine is installed in aircraft, the oil with which it has been lubricated during storage is to be drained off.

8. *External Preservation.*—All exterior bright parts of the engine must be kept coated with an approved rust-preventing material. External aluminium parts which are not protected by enamelling or paint must be similarly treated.

9. *Turning of Engines.*—The crankshaft or crankcase should be rotated for several turns at least once in three months (more frequently if possible), care being taken to ensure that the final position of rest differs from that originally taken up, so that the relative position of the pistons in cylinders is changed.

An engine which has been maintained in store under these conditions for a period of six months or over (except in aircraft) should be internally inspected for corrosion, and such corrosion removed before being subjected to bench test or installation in aircraft.

10. *Removable Parts.*—In any case in which easily removable external parts are liable to damage if they remain on the engine, they should be removed, thoroughly greased, wrapped up in greased paper, or rag saturated with oil, and secured to the engine.

11. *Entries in Log Book.*—A record should be made in the log book whenever an engine is treated as above, such record to be endorsed by a responsible officer.

Engines in Aircraft :

12. Engines stored in aircraft, if they are lubricated as laid down above, should remain in a state of good preservation indefinitely, provided that a brief period of running at low speed is carried out at least every three months, additional oil being injected to the cylinders as already indicated, during intervals between running.

Care of Accumulators.

Specific Gravity of Electrolyte :

13. It is important that electrolyte of correct specific gravity is used. This should be 1·22. Mix with distilled water, adding acid to water, and not vice versa.

Brimstone acid is the best.

Filling :

14. Accumulators should be filled with electrolyte to level of tops of plates. This should be maintained. A cell should never be filled, or even washed out, with plain water—diluted acid should be used.

First Charges :

15. First charges should be slow—the charging rate is generally shewn on the accumulator. This is usually about ⅛ of normal rate.

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This charging rate should be reduced if temperature rises above 100° F.
The signs of being fully charged are :—Constant cell voltage, together with constant specific gravity of electrolyte.

Testing an Accumulator :

16. Fully charged, the voltage per cell should be approximately 2·5. On discharge this falls rapidly to 2·2 volts, and then more steadily to 2·0 volts; below this again more rapidly to 1·8 volts, below which an accumulator should never be discharged.
The specific gravity of the electrolyte forms a good indication of the state of a cell. If the specific gravity has fallen to 1·18, the cell has been discharged to its limits.

Storing Accumulators :

17. Accumulators which are not required for use should be properly filled, charged up, terminals greased, and stored in a dark place. They will retain their charge for a long period, but an occasional short charge is useful and ensures them being in instant readiness.
Accumulators should not be stored in a run-down condition.

Transit :

18. Electrolyte may be emptied when accumulators are being despatched but they should be refilled and charged as soon as practicable.
They should not be left more than a few days empty and uncharged.

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Chapter VI.

MECHANICAL TRANSPORT.

34. Care and Maintenance, General.

1. Attention to Detail :

It cannot be too strongly emphasised that constant supervision and strict attention to detail will make all the difference in the running of a vehicle.

The most essential thing is the greasing and oiling. This point rarely has sufficient attention and many breakdowns are caused by lack of care in this respect.

Vehicles well greased ride better, last longer, are much easier to handle and require fewer replacements.

Every driver, no matter how many hours daily he is on the road, has plenty of time to go round his vehicle and give the greasers a turn or two while waiting.

Defects, however small, should be reported and remedied as soon as discovered. A short time spent in repairing a small tear in the hood, or replacing a missing bolt or greaser, often saves a costly renewal.

External cleanliness should be attended to after engine and interior have received attention.

2. Inspections :

Should be made daily and weekly as detailed.

With regard to weekly inspections, each vehicle should have one day in during every week at which a thorough inspection should be made as detailed.

3. Lubrication :

Oil.—Always maintain correct oil level in engine, gear box and back axle. Do not over-fill. Remove old engine oil every 1,500 miles and refill.

Greasers.—Always wipe the outside of the greaser and thread in position before removing to recharge; otherwise grit will be mixed with the grease to the detriment of the bearings. Occasionally clean out the grease leads with a piece of wire to remove any dirt or solidified grease.

4. Radiator :

Use strainer when filling and keep filled to top.

Radiator dash-board stay should be under light tension and lock-nuts tight.

Fan-belt drives efficiently when slack. Adjust to light tension only.

Empty radiators in frosty weather. Ensure that no water is left in the cylinders, water pipes or pumps.

(i) Open tap, or take out plug, in radiator and allow water to drain off from all parts of system, special care being taken to see that pump is *completely emptied.*

(ii) Turn off petrol and run engine on petrol remaining in carburettor.

Immediately water is emptied out a notice should be hung on radiator cap stating that the vehicle is without water.

If a vehicle is required to stand by for emergency the bonnet should be covered and the engine run for a few minutes every half-hour in frosty weather.

5. Transmission.

Gears.—Noisy gears generally indicate faulty gear wheels, but noise on all gears indicates faulty ball-race. For the gears to come out of mesh when driving is result of gears not meshing correctly, due to strained selector rod or arm. Gears should be examined every 1,000 miles, or two weeks, whichever comes first.

Clutch.—If difficulty is met when changing-up, the clutch stop is too far away. If difficulty is met when changing-down, the clutch stop is too near.

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Steering.—The wearing of a "flat" on a front wheel tyre generally indicates that that wheel is out of alignment. Test and correct. Heavy steering is sometimes the result of dry swivel pins. Occasionally force oil through by means of the greaser. Test for steering wheels overlooking on either side and correct by means of set screws in steering box. See that main steering arm is tight on sector shaft. Keep steering joint leathers packed with grease.

Back Axle.—See that nuts of axle casing are tight. Back axle stay rods should be adjusted to a very light tension only.

6. Chassis :

Springs.—Vehicles should be jacked up periodically so that the spring leaves are in extension and a mixture of oil and graphite should then be injected between the leaves of the springs, obviating rust and ensuring lubrication and proper working.

Stationary Vehicles.—Blocks of timber should be inserted under the frames of all vehicles which are stationary for any length of time, relieving the tyres of the weight of the vehicle and obviating the possibility of "flats" being created on the tyres.

Tyres should be protected from fierce sun by sacking or other suitable means.

Tyres.—Cars and tenders are orginally issued with studded tyres fitted diagonally on the wheels, and this method of fitting should be maintained—that is to say, studded covers should always be replaced with studded covers. All tyres should be kept up to pressure recommended by the tyre manufacturers. The average pressure is, for back wheels, 70 lbs. to 80 lbs.; for front wheels 60 lbs. to 65 lbs. per square inch.

Remove any stones which may lodge in between tyres of twin wheels, solid or pneumatic.

Cleanliness.—It is important that all under-trays, engines, gear boxes and chassis parts be kept clean and free from rust. Paraffin should be used to clean only those parts where grease collects; the use of paraffin spoils all paint and varnish.

7. General :

Nuts.—Go over all nuts periodically and tighten; doing this often prevents serious damage and unnecessary wear.

Chains.—Remove periodically, soak thoroughly in paraffin, then dry and put into a bath of hot graphite and tallow, or graphite and oil.

Filters.—Clean oil and petrol filters periodically.

Lamps (Oil).—Keep reservoir full and wicks trimmed.

Lamps (Acetylene).—Drain water reservoir in frosty weather.

Lamps (Electric).—See that all lamps light, and that accumulator acid-level is correct, terminals cleaned and vaselined, and plug in top of accumulator case tight, to prevent spilling of acid.

8. Driving :

All engines *must* be stopped when the vehicles come to rest.

Drive on the throttle and use the brakes only when absolutely necessary. Excessive or violent braking indicates faulty judgment, wears out brake shoes, and is bad for the car and its tyres.

Starting.—All cars should be started with an upward pull and with thumb and fingers on the same side of the starting handle.

Speed Limits.—Must be strictly observed and speed reduced over bad roads. Speed limits should be set by a unit over all rough or dangerous roads in its vicinity.

9. Log Books (Book 412) :

These must be written up each night, the writer giving a full account regarding replacements, accidents and general running. A specimen log-book sheet is shown on p. 179, and the following rules should be observed :—

(1) All repairs, "running" or otherwise, must be entered, stating work done, materials used and mechanism employed.

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(ii) Changing of oil in sump every 14 full working days must be recorded.
(iii) An entry should be made in respect of each fortnightly tool check.
(iv) All entries to be signed by workshops officer.

TUNING GENERALLY.

10. **Engine :**

Failure to pull well may be due to one or more of the following faults :—
(i) *Poor Compression.*—To test, open throttle fully, pull engine over slowly by hand. Locate cylinder with faulty compression, then look at
(ii) *Valves.*—The tappet clearance should be 5/1000's of an inch if correct. Remove valves and see they are seating correctly. Valves may require grinding in. Valve head may not be true with valve stem. Valve seatings may be bad. Valve springs may be weak. Test for leaks from valve caps and compression taps.
(iii) *Sparking Plugs* may be loose or have cracked porcelains. They may require cleaning.
(iv) *Magneto.*—Make and break points should be clean and properly adjusted.
(v) *Carburettor.*—See that petrol flow and jets are clear and correct jet setting is maintained.
(vi) *Piston Rings* may be faulty. Remove cylinders and replace.
(vii) *Cylinders* may require decarbonising.

35. SPECIAL NOTES ON CARE AND MAINTENANCE. CROSSLEY.

INSPECTION ROUTINE AND SPECIAL ADJUSTMENTS.

DAILY INSPECTION.

1. All greasers should be turned and the vehicle inspected for missing parts, grease caps, loose nuts, etc. Particular attention should be paid to the grease caps which are least accessible, as these are very frequently overlooked.
See that oil level in engine sump is correct. Give all oilers a few drops of oil. Oil coupling shaft from flywheel to gear box.
See that radiator is full and tyres properly inflated.
Attend to lamps.
Fill up petrol tank.

WEEKLY INSPECTION.

2. **Oiling :**

Engine.—Examine and maintain correct oil level; indicator to show ½ way up. Use Mineral Thin for cold weather and Mineral Thick for warm weather.

Note.—Oil in sump should be drained off after 1,500 miles and replaced by fresh oil. At the same time filter should be cleaned in paraffin, using stiff brush. Run engine dead slow for 10 minutes after this operation.

Gear Box.—Examine and maintain correct oil level, *i.e.*, to top of lay shaft. Mineral Thick oil must be used. Grease *must not* be used on any account.

• *Back Axle.*—Examine and maintain correct oil level, *i.e.*, to level of top of filler cap. Thick engine oil may be used, but *not* grease.

Magneto.—Put one or two drops of oil on magneto bearings. Excessive oil on magneto causes ignition trouble.

Various.—The following should also be kept oiled :—
Spring platforms.
Starting handle bush.
Fan bearings.
Brake and clutch cross shaft.
Steering box through oiler on steering column
Change speed cross shaft.
Rear brake operating spindle.
Remove wheels and oil locking rings.

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Specimen of Log Book Sheet.

Date and Time in Shops.		Nature of Defect and Repairs.	Replacements and Stores used.	Names of Fitters.	Signature of Officer i/c Workshops.
In.	Out.				
26.7.21	26.7.21	Engine sump cleaned out; refilled with fresh oil.	2 gallons Vacuum BB Oil	L/Acm. Smith L/Acm. Jones	R. Frost, Flying Officer Officer i/c Transport.
29.7.21	30.7.21	Tools and equipment checked. Deficient—1 wire wheel spanner.	1 wire wheel spanner. Driver—L/Acm. Brown.	Checked, F/Sgt. Baker.	R. Frost, Flying Officer, Officer i/c Transport.
3.8.21	4.8.21	Front axle bent in collision with Heavy Tender T.1210.	New front axle fitted U/s front axle returned to "Z" A.P.	Cpl. Miller. Ac/1 Robinson.	R. Frost, Flying Officer, Officer i/c Transport.

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3. Greasing :

All grease lubricators to be refilled.
The following must be kept greased :—
Road wheel bearings.
(*Note.*—Axle hubs should be filled *monthly*.)
Steering swivel.
Steering joints.
Clutch trunnion.
Outside of torque ball.

4. Cleaning :

Petrol Filter.

Tank.—Remove plug from bottom of tank and clean out sediment.

Carburettor.—Remove float chamber and clean out any sediment.

Magneto.—Distributor and platinum points.

Sparking Plugs.

5. Adjustments :

Take up play in all steering joints with car jacked up.
Tighten wheels on hubs and butterfly nuts of security bolts on wheels.
Adjust foot and hand brakes.
Adjust oil pressure if necessary.
Adjust sparking plug gap to 1/32 in. In the case of multiple point plugs, one point only need be set to the above limit; the remainder may be set to 3/64 inch.
Adjust valve tappets if necessary.

Caution.—The jet setting and petrol level in the carburettor must on no account be changed.

Examine the following parts for fractures :—
Rear spring frame brackets.
Off-side chassis member at gate.
Both chassis members at radiator trunnion.
Radius rods on both front and rear ends.

Special Adjustments.

1. Carburettor

Diagram gives standard setting and sequence of operation, which must not be departed from :—
It will be found advisable to increase the Pilot Jet from size 35 to size 37 when the inlet valve guides are at all worn.

2. To set Camshaft :

Correct position is exhaust valve to close at top dead centre with 5/1,000's of an inch tappet clearance. Inlet opens 1¼ ins. after T.D.C.

3. Timing Magneto :

Set No. 1 piston on top dead centre on firing stroke; retard magneto and set with points just breaking. Firing order: 1, 3, 4, 2.

4. Lubrication :

Always watch gauge when starting. If no indication of oil circulating shown, prime oil pump, taking care to close tap afterwards. When engine oil is cold the gauge may show up to 25 lbs., which should drop to normal (5–10 lbs.) as engine warms up. If high pressure is maintained when engine is hot, correct pressure. *Unscrewing* cap nut on pressure valve *lowers* pressure; *screwing-up* cap nut on pressure valve *raises* pressure.

5. Pump Chain :

Adjust to very light tension only.

6. Timing Wheel and Chain :

Adjust so that there is about ⅛ in. movement registered on driving wheel (*the lower one*) of the pump. Chain must be adjusted to its tightest

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position; tension varies, due to unequal chain wear. After effecting the adjustment, take care to align magneto correctly.

7. Clutch :

If fierce, treat clutch lining *very sparingly* with oil. If no improvement, the engine and gear box may be out of alignment. This can be tested with universal joint dismantled, scriber attached to gear box coupling and checking against inside diameter and outer face of flywheel. If clutch does not spin freely when clutch pedal is depressed, spigot bush may be dry. This bush should be lubricated frequently.

Give 1 in. pedal movement on end of clutch pedal arm when clutch is fully engaged.

8. Rear Axle :

Oil leaks generally indicate slack nuts. See that locking rings of cardan shaft ball-joint are tight. To test backlash or wear in transmission, jack up one rear wheel, engage fourth speed, apply foot brake, and note movement on circumference of rear wheel, which should average about 1 in.

9. Wheels and Bearings :

Front wheel bearings are Timken roller adjustable. These must be kept free from end-play, which can be corrected by means of nuts on end of swivelling axles. The same remarks apply to the back rear wheel bearings.

To ensure that the inner bearing of the front wheel gets properly lubricated, force grease right through until it emerges on the inner or axle side.

10. Brakes :

Keep both foot and hand brakes properly adjusted. After adjusting they must be tested for freedom by means of jacking up rear wheels and spinning by hand. If either brakes are fierce or squeak, treat *sparingly* with oil. Keep all brake connections well lubricated.

LEYLAND.

Inspection Routine and Special Adjustments.

Daily Inspection.

1. All greasers should be turned daily and the vehicle generally inspected for any missing parts, grease caps, etc.

See that oil level in engine sump is correct.

Oil daily :—

Clutch Spigot.—Remove plug in flywheel cover and turn clutch shaft until hole in same is opposite the slot in clutch adjusting nut.

Cardan Shaft.—Through hole in centre which lubricates the four dies.

Front Road Wheels.—By two oil plugs.

Rear Road Wheels.—By two oil plugs.

Cardan Die Boxes.—By two oil plugs.

Spherical Thrust Member.—By one oil plug.

Fill up petrol tank.

Attend to lamps.

Weekly Inspection.

2. Oiling :

Engine.—Examine and maintain correct oil level, *i.e.*, top of wire indicator is level with groove marked on outside of metal case.

Note.—Oil in sump should be drained off after 1,500 miles and replaced by fresh oil. At the same time filter should be cleaned in paraffin, using stiff brush. Run engine dead slow for 10 minutes after this operation.

Gear Box.—Examine and maintain correct oil level. Use heavy cylinder oil, and *on no account* grease. The quantity required brings the oil level up to the higher of the two cocks placed on the near side of the gear box.

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The lower one is intended to shew the minimum level and when the oil gets below this more must be added.

Back Axle.—Examine and maintain correct oil level. Fill to top of filler cap. Heavy cylinder oil should be used. Grease must *on no account* be used.

Magneto.—Put only one or two drops of oil on magneto bearings weekly. Excessive oil on magneto causes ignition trouble.

Various.—The following should be also oiled weekly :—

All steering connections and steering column box.
Side brake connections.
Foot brake connections.
Clutch pedal sleeve and declutching ball-race.
Road wheel caps.

3. **Greasing :**

Refill all lubricators on chassis.
The following must be kept greased :—

Spring shackle bolts.
Steering gear ball joints.

(*Note.*—Leather coverings of steering gear should be removed for inspection and refilled with grease *monthly.*)

Coupling shaft boxes (by removing plugs).
Front cardan box (by removing plug).
Rear cardan box (by removing semi-circular plate from thrust bracket).

4. **Cleaning :**

Petrol filter.
Carburettor.—Remove float chamber and clean out any sediment.
Magneto.—Distributor and Platinum points.
Sparking plugs.

5. **Adjustments :**

Take up play in all steering joints.
Adjust hand and foot brakes.
Adjust valve tappets if necessary.
Examine the following parts :—

Front spring clips; these often work loose.
Arm on steering column; if allowed to become loose on worm-wheel shaft considerable damage is done to the steering.
Centre bearing bolts on engine occasionally become loose. These must be tightened when necessary.
Propeller tube; this occasionally fractures close to the torque ball.
Rear axle casing: fractures radiate from side axle tubes.

Note.—All road wheels should be removed *once a month* to see that the backs of the wheel bearings are getting grease; at the same time the wheels can be examined to see if the rivets are working loose.

Special Adjustments.

1. **To set Camshaft :**

Correct position is : Exhaust valve to close at 1 in. after top dead centre, with 5/1,000's of an inch, tappet clearance.

2. **Lubrication :**

Always watch oil indicator when starting to ensure that the oil is circulating.

3. **Timing Magneto :**

Set No. 1 piston on top dead centre on firing stroke. Advance ignition lever one quarter of its travel and couple up magnets with points just breaking. Firing order : 1, 3, 4, 2.

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4. Clutch :

If fierce, treat clutch lining *very sparingly* with oil. If no improvement, the engine and gear box may be out of alignment, or rivet may be protruding beyond clutch lining. Should the clutch slip, adjust by tightening up the slotted nut, after having first slacked back the locking screw in the boss of flywheel cover.

Give ¼ in. pedal movement on end of pedal when clutch is fully engaged.

The locking screw also acts as an oil plug for lubrication of the clutch sleeve. This should be removed for oiling every 100 miles. Care must be taken (when replacing the oil plug after having made an adjustment to the clutch spring) to see that it enters the slot provided in the clutch adjusting nut. An arrow marked on this nut indicates correct position.

5. Rear Axle :

Oil leaks generally indicate slack nuts.

6. Wheels and Bearings :

Front bearings.—Lubricate floating bushes with heavy oil only forcing same in until oil emerges from axle side of bearing.

For the rear axle floating bushes, use oil only.

7. Brakes :

Keep both foot and hand brakes properly adjusted. After adjusting they must be tested for freedom by means of jacking up rear wheels, which should then be spun by hand.

Foot Brake.—An adjustable stop is provided underneath the bottom brake-shoe. It is most important that this also should be regulated to give the correct amount of clearance between the shoes and foot brake drum at the same time as the wing nut adjustment is made.

WORKSHOP LORRIES.

1. The lorry engine of a workshop lorry should be started up occasionally and the lorry taken for a trip to ensure that it is perfectly mobile.

Tools and equipment should be frequently checked and the repairs to the machinery should be carried out without delay.

When the shop is likely to stay in one place for any length of time, packing blocks should be placed between the chassis and the ground to save the lorry springs and make the shop rigid. This will enable better work to be done on the lathe.

2. The lighting set runs at a very high speed and the oil in the sump needs very frequent changing. The various motors and dynamo in the workshop require oiling and occasional attention to the brushes will prevent sparking on the commutator. Care should be taken to keep the commutator quite free from any trace of oil. The mechanic in charge should occasionally wipe the commutator when the dynamo or motor is running. This should be done with a soft cloth. The proper fuse wire should always be used for the fuse board.

P. & M. MOTOR CYCLES.

1. Lubrication :

Automatic pump should discharge its contents every eight miles, or every five miles when running with side-car.

2. Gears :

When changing gear always press the gear lever well home. Lubrication of gear main double ball bearings is of the utmost importance, also of the thrust ball bearing to which the wedge bars are attached. Do not put any pressure on the red oil lubricator when forcing in oil, or it will break off. After about 8,000 miles the wedge bars may require expanding. This is necessary when the gear will not hold, but slips. Do not confuse this with clutch or engine shaft slipping. This can be verified by placing the gear lever firmly in high gear and pulling the back wheel sharply against compression, when the high gear chain will revolve a short distance, separately from the low gear, if slip is taking place. To correct, the outer nut should be firmly locked against the inner and a little oil injected through the hole in the distance piece.

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3. **Brakes :**
Keep both front and rear brakes properly adjusted and test for freedom with wheels off ground.

4. **Wheels and Bearings :**
Always keep the bearings of both front and rear wheels well lubricated and correctly adjusted. They revolve (owing to their size) many more times than the wheels of a car.
Watch wheel spokes, particularly back wheel spokes. Keep them at proper tension.

5. **Head Bearings :**
These must be kept adjusted without any slack (up and down play) at all. Test for this by means of lifting on handle bars.

6. **Chains :**
Keep these properly adjusted in the tightest position. Slackness is the result of unequal wear on chains.

7. **Spring Forks :**
Keep all moving parts well lubricated.

8. **Nuts and Bolts :**
See that all nuts are tight.
Bolts should be frequently gone over and checked, particularly :—
Bolts holding tanks to frame.
Front and rear mudguard bolts.
Front and rear carrier bolts.

P. & M. SIDE-CAR.

1. **Wheels :**
Bearings and spokes (*see* remarks under P. & M. Cycle).

2. **Springs :**
Periodically inject oil between all leaves.

3. **Petrol Can Holder :**
This should not be fitted to extend *backward* from the under frame —and *not* inward.

4. **Alignment :**
See that side-car is correctly aligned with the cycle, or excessive tyre wear and difficulty with steering will result. On no account should kick starter be used until half compression plate has been raised and spark retarded; otherwise breakage of starter will result.

TRAILERS.

1. **Springs :**
Oil between all the leaves periodically. Remember to oil the springs shackle pins. Where greasers are provided, keep supplied with grease and give one or two turns at regular intervals.

2. **Truss Rods :**
These must be kept bolted up tightly to the ends of frame and cross buttresses.

3. **Wheel :**
Timken adjustable bearings should be kept correctly adjusted; never run with slack bearings. Keep hubs well greased.

4. **Perch Pole :**
The side members (outer) of Mark I. Trailers must be extended with the pole; otherwise the pole—with increasing leverage—is apt to get permanently "set." Such trailers should not be extended unless required.

5. **Eyed Draw-Bolt :**
Keep this greased and working freely.

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36. GENERAL NOTES ON MOVEMENTS.

General :

1. Plans should be prepared shewing exactly what each lorry is to carry, and the order of loading, ready for a move at short notice.

When possible, an Officer should be detailed to go round the camp the last thing before moving off to ensure that it is left in proper order, and a fatigue party should be detailed if necessary to remain until this inspection has been carried out.

Speed :

2. When lorries move in convoy an officer must be responsible for setting the pace at the head. This pace must be a very moderate one, and should normally not exceed eight miles per hour where heavy tenders are in the convoy. It is frequently necessary for lorries in the rear to travel at almost double the pace of the leading vehicle in order to keep position.

Spacing :

3. It is convenient to split a convoy up into sections of about six vehicles, with a larger interval between the sections.

Lorries in a convoy should not travel at an interval of less than 20 yards between, and if moving at full speed this distance should be increased to 100 yards.

Halts :

4. Convoys should halt every ten or fifteen miles and the Officer in charge should satisfy himself that everything is in order, trailer loads are not slipping, and tyres are not flat. If a good watch is not kept it is possible to run a trailer for considerable distances with tyres down, thereby ruining them completely.

A halt should be called after going up a long hill to ensure that the column is not opening out. Care should be taken, however, that the head of the column is sufficiently far past the hill to ensure that the rearmost vehicles do not have to halt on the hill.

It should be remembered that lorry driving on rough or greasy roads is a tiring job, and dust seriously affects a driver's powers of endurances Halts are, therefore, necessary on this account.

Warning of Blocks, etc. :

5. When practicable, motor cyclists should move at the head of a column to give warning of any likely blocks or bad roads. In the case of a bad road it may be necessary to send on a party of men with picks and shovels to fill up holes, which may otherwise cause a broken spring or even a broken axle.

Oneway Roads :

6. If necessary to proceed by a narrow road where there is insufficient room for vehicles to pass, cyclists should be sent to the further end of the defile if there is likelihood of vehicles coming in an opposite direction and requiring to pass.

Guides :

7. When moving by night or on a road difficult to follow, it may be necessary to place men at points to act as guides. Under these circumstances the leading lorry should carry a sufficient number of men to enable one to be dropped at such points with orders to direct the convoy along the right road. Each man must know the number of vehicles in the convoy, and the registration number of the last vehicle. He remains there until the last vehicle reaches him, and then accompanies it. This, of course, necessitates the last vehicle starting wholly or partially empty.

Keeping Touch :

8. If practicable two motor cyclists should follow at the rear of the column, each reporting to the officer in charge at the head of the column at regular intervals, stating whether all is correct, or at once in the event of a vehicle breaking down.

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37. NOTES ON RESCUING M.T. VEHICLES.

If a vehicle gets ditched, the best method of procedure is as follows :—

1. Lorries :

If a lorry is ditched it generally makes matters worse to try and get it out under its own power. If the rear wheel is not badly ditched, however, the lorry can often be got out by engaging first speed or reverse, as the case may be, opening compression cocks, switching engine off, and turning the engine round by hand. This gives a nice, easy motion, and is successful in simple cases.

Towing.—A Leyland lorry will nearly always tow out another one unless the latter is very badly ditched indeed. It is usually simpler to pull a lorry out backwards, but much depends on the circumstances. If badly ditched, clear all wheels free with a spade, make a path for the wheel tracks, and tow. Avoid locking quickly, if possible, as this makes extra work for the salvage lorry. In towing a lorry, never attach the tow rope to the axle. Use the towing hooks and get as straight a pull as possible. See that the under shields are clear of the ground, or they will get bent.

Salvage Work.—For salvage work, short pieces of timber about 9×3 in. are very useful and should be carried. If another lorry is not available it is necessary to dig the wheels out and lay a timber or other hard track to enable the driving wheels to get proper grip. Otherwise the lorry will simply dig itself in.

If the ditched vehicle is loaded it usually saves time in the end to tranship the load to another lorry.

2. Cars and Light Tenders :

The same method will remove a car or light tender, but a Leyland towing rope should not be used, or the dumb irons and springs will probably get bent. Hemp rope should be used if available; if not, wrap sacking round the dumb iron and spring before attaching chain end.

Do not pull out the car by attaching to the jockey spring at rear. There are plenty of more suitable places on the frame to which a good fixing can be made—depending, of course, on the position of the car in the ditch.

Towing.—When towing vehicles, use one tow rope attached to one dumb iron only. If two are used the chassis is almost certain to get strained. Never let the towed vehicle overrun the tow rope, and avoid jerks. The strain should be taken up gradually on the tow rope when starting.

38. USEFUL INFORMATION ON MECHANICAL TRANSPORT.

Dimensions and Weights.

Vehicles.	Length.	Width.	Height with Hood.	Weight unloaded.
	ft. ins.	ft. ins.	ft. ins.	Tons Cwts. Qrs. Lbs.
P. & M. M/Cycle - -	6 10	3 0	3 1	– 2 0 26
P. & M. M/Cycle and S/Car - - -	6 10	5 3	3 1	– 3 1 11
Rolls Royce Landaulette - - -	16 1	5 10½	7 1	2 5 0 0
Crossley Touring Car -	16 4	6 1	7 0	1 18 1 0
Crossley Tender with driver and full tanks	17 0	6 1	8 6	1 17 1 0
Leyland Lorry (Heavy Tender) with driver and full tanks - -	22 0	7 0	11 0	4 5 1 0

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Vehicles.	Length.	Width.	Height with Hood.	Weight unloaded.
	ft. ins.	ft. ins.	ft. ins.	Tons. Cwts. Qrs. Lbs.
Leyland Lorry (Bomb) with driver and full tanks	22 0	7 8	11 8	4 15 1 0
Leyland Lorry (Workshop with extensions and fully extended)	26 0	12 9	11 6	6 19 0 0
Sentinel Steam Wagon, with driver and full tanks	20 5	7 5	8 6	5 1 0 0
Trailer Flat (Mk. Ia)	24 0	6 9	3 6	— 15 0 0
Trailer Crocodile	26 4	7 2	4 0	1 8 0 0
Trailer Sentinel, rubber tyred	18 4	6 8½	6 5½	1 19 3 0

Capacities and Consumption.

Vehicles.	Capacity of Tanks Petrol.	Capacity of Sump Oil.	Average Consumption Miles to Gallon.	
			Petrol.	Oil.
	Gallons.	Gallons.		
P. & M. M/Cycle	1½	3 Pints (tank).	70	1000
P. & M. M/Cycle and S/Car.	1½	3 Pints (tank).	50	752
Rolls Royce Car	20	1½	10	500
Crossley Touring Car	18 + 2	2½	14	500
Crossley Light Tender	18 + 2	2½	12	450
Leyland Lorry	28	3	6	200

Dimensions of Chassis.

	Feet.	Inches.
Rolls Royce Wheel Base	11	11½
Rolls Royce Track	4	8
Rolls Royce Overall Length	15	8½
Rolls Royce Overall Width	5	10½
Crossley Wheel Base	11	3½
Crossley Track	4	10
Crossley Overall Length	15	6½
Crossley Overall Width	5	11½
Leyland Wheel Base	14	1
Leyland Track	5	7

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Space occupied by Transport of a Squadron.
(Light and Heavy Tenders only.)

	Single Seater Fighter (Yds.)		Corps Reconn. (Yds.)		Bomber (Single Engine) (Yds.)		Bomber (Twin Engine) (Yds.)	
	Home.	*Abroad.	Home.	*Abroad.	Home.	*Abroad.	Home.	*Abroad.
Frontage in line with 3 ft. space	28	57	28	57	28	57	28	70
Column of route with 4ft. interval	70	143	70	143	70	143	70	173

* Excluding Iraq.

Note.—If any one vehicle is required to be detached when in column of route, four feet is minimum distance to enable this to be done, on good ground. If vehicle should not be backed, double the distance allowed. Extra allowance is needed for soft ground.

Above figures are based on establishments, shewn on page 191.

Quantities required for Repainting (One Coat).

	Pints
Crossley Touring Car	4
Crossley Limousine	4
Crossley Light Tender	4
Leyland Heavy Tender (Float)	7
Leyland Heavy Tender	8
Motor Cycle and Sidecar	1

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Bridge Loads due to Mechanical Transport.

Vehicle.	Weight fully loaded. Front Wheels.	Weight fully loaded. Hind Wheels.	Distance Axle to Axle.	Overall Width.	Overall Height.	Wheel Track.	Width of Roller.	Width of Tyres.
	Tons.	Tons.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.
Light loads—								
Ford box car	0·50	0·55	8 3	5 8	7 6	4 8	—	0 3½ single
Ford ambulance	0·50	0·55	8 3	5 8	7 6	4 8	—	0 4½ twin
Touring car	0·90	1·00	10 10	5 9	6 7	4 8	—	0 4½ ,,
Garford water lorry	0·30	1·25	10 1	5 11	6 9½	5 6	—	0 3½ ,,
Heavy limousine	1·25	1·50	12 0	6 0	7 6	4 8	—	0 4½ ,,
Heavy box car	0·90	1·75	11 6	6 2	8 2	4 8	—	0 4½ ,,
Heavy ambulance	0·90	1·75	11 6	6 2	8 2	4 8	—	0 4½ ,,
Medium loads—								
30 cwt. lorry	1·50	3·50	11 8	6 6	10 6	5 3	—	0 4 twin
F.W.D. lorry	2·50	3·50	10 4	7 6	10 6	4 8	—	0 6 single
A.A. gun, 13-pounder	1·50	4·00	13 8½	6 6	—	5 7½	—	0 5 twin
Electric light lorry	2·50	4·50	13 6	7 6	10 6	6 5	—	0 5 ,,
Heavy water lorry	1·20	5·00	14 2⅜	7 1⅜	—	5 8	—	0 5 ,,
Motor bus	2·00	5·00	13 0	6 9	12 9	6 6	—	0 5 ,,
Kite balloon	2·00	5·00	13 10½	7 4	11 0	5 6	—	0 5 ,,
								0 4 single front
Berna lorry	4·50	5·40	13 1½	7 3	10 2*	5 0	—	0 5 double rear

* Height unloaded.

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Bridge Loads due to Mechanical Transport—*continued.*

Vehicle.	Weight fully loaded.		Distance Axle to Axle.	Overall Width.	Overall Height.	Wheel Track.	Width of Roller.	Width of Tyres.
	Front Wheels.	Hind Wheels.						
	Tons.	Tons.	Ft. Ins.	Ft. Ins.	Ft Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.
3 ton lorry	2·50	5·50	13 6	7 6	11 6	6 7	—	0 5 twin
Searchlight lorry	2·50	5·50	13 6	7 6	11 6	6 7	—	0 5 ,,
F.W.D. trailer (7 ton)	3·80	5·70	10 4	7 5	4 9*	6 7	—	0 4 ,,
Light petrol roller (Barford & Perkins, type E.2)	1·80	5·90	7 6	6 0	9 6	4 0	4 0	4 0†
Water sterilising lorry (Foden)	4·00	6·50	14 0	7 0	8 2	6 0	—	0 6½ ,,
Foden disinfector	3·25	7·25	14 4	7 6	10 0	7 0	—	1 0
10 ton steam roller	5·25	7·50	11 0½	6 4½	10 0½	6 4½	4 0	1 4½
Petrol roller (Barford & Perkins, type J)	4·40	7·75	11 8½	6 8½	9 6	4 6	†4 6	4 6
Foden lorry	4·00	8·00	16 4	7 6	8 3	7 0	—	1 0
Heavy commercial lorry	3·00	8·00	13 7	7 9	12 0	6 11	—	0 11
Heavy loads—								
Heavy petrol roller (Aveling & Porter, 14 ton)	5·05	9·10	11 0	8 1	10 0	5 4	†5 4	Roller 5 4
Petrol tractor (Holt 11 ton caterpillar)	1·40	10·10‡	11 3‡	8 9	10 0	8 9	—	—
17 ton steam roller	6·75	11·75	12 7½	7 5	11 1½	7 5	4 4	1 8
Fowler steam tractor (16 ton)	4·15	12·35	10 3½	7 7½	12 1½	7 7½	—	Front 9 in. Rear 18 in.

* Height unloaded. † These have rollers rear and front; figures are for rear rollers.
‡ Load on caterpillar. Distance is from front axle to centre of caterpillar. Length of caterpillar is 9 ft. 6 in.

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Establishments of M.T. Vehicles.

	Army Co-operation Squadrons.			Bombing Squadrons (single engine).			Bombing Squadrons (twin engine).			Single Seater Fighter Squadron.		
	Home.	Abroad.	Iraq.	Home.	Abroad.	Iraq.	Home.	Abroad.	Iraq.	Home.	Abroad.	Iraq.
	Est. No. I.A. 355 dated 17.9.24	Est. No. E.A.308 dated 1.4.23.	Est. No. M.W.307 dated 1.4.23.	Est. No. I.A. 319 dated 1.4.23.	Est. No. E.A.307 dated 1.4.23.	Est. No. M.W.308 dated 1.4.23.	Est. No. - - dated - -	Est. No. E.A.310 dated 1.4.23.	Est. No. M.W.309 dated 1.4.23.	Est. No. - - dated - -	Est. No. - - dated - -	Est. No. M.W.306 dated 1.4.23.
Touring cars	1	1	1	1	1	1	No Squadron Establishment, all Station Transport Pooled.	1	1	No Squadron Establishment, all Station Transport Pooled.	No Squadron Establishment, all Station Transport Pooled.	1
Light tenders	5	7	1	4	7	1		7	2			1
Heavy tenders	4	11	—	5	11	—		15	—			1(a)
Ambulances	1	1	—	1	1	—		1	—			—
Motor Cycles	3	5	1	2	5	1		4	2			1
Side cars	2	4	1	2	4	1		3	1			1
Repair lorries	1	2	2	1	2	2		2	2			2
Trailers I. A.	4	8	—	4	8	—		8	—			—
Trailers H.P.	—	—	—	—	—	—		—	—			—
Trailers, wing	1	1	—	1	1	—		—	—			—
Trailers water cart	1	1	—	1	1	—		1	—			—
Bicycles	1	1	1	1	1	1		1	1			1
Hucks starters	1	1	1	1	1	1		1	1			1
Tractors	—	—	—	—	—	—		1	—			—
Total	25	43	8	24	43	8		47	10			9

(a) Fitted with Searchlight.

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CHAPTER VII.

39. WORKSHOP NOTES.

Brazing and Soldering.

1. Fluxes :

(i) Spirits of Salts (Commercial Hydrochloric Acid) in which zinc has to be dissolved to the point of neutralisation. (ii) Special R.A.F. Flux. (iii) Fluxite. (iv) Salammoniac. (v) Resin. (vi) Borax.

For soldering steel, use (i), (ii), (iii).
For soldering brass or copper, use (i), (iii), (iv).
For soldering lead alloys, use (i), (iii), (iv), (v).
For brazing or silver soldering all metals, use (vi).

2. Soft Soldering :

Soft soldering is the uniting of two pieces of metal by means of a fusible alloy below red heat. It is the simplest way of joining metals, but also the weakest joint.

Soft Solder is an alloy of lead and tin with the addition of bismuth.

Melting Points of Soft Solders.

Lead.	Tin.	Bismuth.	Melting Point Fahrenheit.
4	4	1	320°
3	3	1	310°
2	2	1	290°
1	1	1	255°

3. Brazing :

Brazing is the uniting of metals by means of a fusible alloy above red heat, and the result is a strong and substantial joint.

Hard Solder or Spelter is an alloy of copper and zinc.

Melting Points of Hard Solder.

Copper.	Zinc.	Melting Point Fahrenheit.
1	1	550°
2	1	700°

It is essential that parts to be soldered or brazed should be thoroughly clean.

Case Hardening.

4. Suitable Steels :

Steels suitable for case hardening have approximately ·20 per cent. of carbon in their composition, and are termed Mild Steels. The surface of such steel may be hardened by increasing the carbon content up to 1·2 per cent. carbon, which is the maximum hardness. This is done by heating the steel in the presence of carbonising material, and the process is termed " case-hardening."

5. Carbonising Materials :

If a specially prepared compound is used the makers' instructions should be followed.

In the absence of a special compound, suitable carbonising materials may consist of charred leather, bone charcoal, prussiate of potash or a mixture of 60 per cent wood charcoal and 40 per cent. barium carbonate.

6. Depth of Penetration :

If only a surface hardness is required the piece should be cleaned, surrounded by the carbonising material and heated to 850° centigrade (cherry red), and then quenched in water. It is often convenient to mix a little water with the case-hardening compound, forming a paste. The work must be clean and heated in pure, radiant heat.

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Where more penetration is required, it is necessary to place the parts n iron boxes surrounded with the case-hardening material, and heat to a temperature of 900° to 950° centigrade, this temperature being maintained from 2 to 6 hours. The work should then be allowed to cool slowly in the box and afterwards reheated to 800° to 850°, and quenched in water. If quenched in oil the surface will be slightly less hard, but the core tougher.

It is not usually advisable to case-harden to a depth much beyond 1/16".

7. Kasenit Compound :

The following instructions are issued by the makers of the above compound :—

For Wrought Iron and Mild Steel.—Heat the work uniformly to a bright red, dip or roll it in the powder, which will melt on and adhere to the surface, forming a shell round same. Re-heat to a bright red, and plunge in CLEAN, COLD water. This will give the article a completely hard, uniform and reliable surface casing.

If a deeper casing is required, repeat the above operation before plunging into water, or allow the work to soak in powder in a suitable receptacle at cherry red heat for from 5 to 30 minutes, depending on the depth required. Then plunge in CLEAN, COLD water.

Wipe the article clean before removing it from the cooling tank.

Malleable and cast iron may be subjected to a considerably higher heat.

For Cast or Tool Steel.—Heat the article to a light yellow. Deposit same in the powder and leave it there until its right tempering heat is reached, then plunge in CLEAN, COLD water. This will bring out the utmost limit of hardness and also prevent cracking.

White Metalling Bearings.

8. White metals for lining bearings are alloys usually composed mainly of tin, with small proportions of copper, antimony and lead.

Notes are given below as to the best methods of securing good results.

9. Tinning :

Clean the bearing thoroughly, heat with the blow-pipe or gas blow-pipe, and tin it carefully with a strip of pure tin. After tinning, wipe out the bearing to remove superfluous metal, and also all traces of flux (which would cause blow-holes), and then give a fair coating of clean tin. See that the blow-lamp flame is quite clean, and heat the bearing from the back. Killed spirits of salts is usually a quite satisfactory flux.

10. Heat :

Great care should be taken not to overheat the metal, which must only be hot enough to run freely and to turn a piece of dry white paper brown (about 600°/650° Fahrenheit, or 316°/343° Centigrade).

If the metal has been slightly overheated, cool at once before using. A metal badly overheated is not as good as before. A bluish ash forming on the surface is mainly oxide of tin, and shews the metal is overheated.

It is extremely important that anti-friction metals be well and frequently stirred. If the metal is to be kept hot for long, it is an advantage to cover it with a thin layer of vegetable charcoal. Provided metals are *not overheated,* they may be melted say three times without injury, but the fewer times the better. Always have a fair quantity of metal in the pot, as the surface exposed to the air (which causes oxidation) is then less in proportion.

Never mix different makes or qualities of White Metal. Do not use old metal from bearings.

11. Filling :

Mount the bearing in the jig, and heat both until the tinned surface *just runs,* and therefore will join with the white metal when it is poured in. Do not make the mandrel too hot. It is best to fill the bearing as high as possible.

To obtain smooth castings, and to avoid blow-holes, make the metal set from the bottom upwards, and keep the top of the casting fluid with the blow-pipe (only a gentle heat is required). Meantime dip a clean

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wire in and out, as far down as it will go without force, until the metal is solid up to the top, which can be finished off smoothly with the blow-pipe.

If the white metal does not stick to a properly tinned bearing, the tinning has been oxidised by making the shell too hot, or the shell has not been made hot enough.

Lined bearings should ring sound when balanced on the fingers and touched with a hammer; if they do not, the metal is not sticking everywhere and must be melted out; but bearings cracked or with many holes or grooves may never ring sound. If the metal is hard, and feels "gritty" when scraped, it has been too hot, and must be melted out. Blow-holes are usually caused by moisture from the "packing," or by flux left in the bearing.

PROPERTIES OF STEELS.

Alloy Steels.

Mark.	Description.	Ultimate Tensile Strength Tons.	Uses.
S.2 -	High Tensile Nickel Chrome Steel.	55	Turnbuckles, Connecting-Rods, Crankshafts and some Gear Wheels. Generally used where particular strength is required.
S.8 -	High Tensile 3 per cent. Nickel Steel.	45	Turnbuckles, Connecting-Rods, Crankshafts and some Gear Wheels. Substitute for S.2 where permissible.
S.14 -	Case-Hardening Steel up to ·20 per cent. Carbon content.	38	Can be used in lieu of S.1 Pt. 2, and S.32. Suitable for welding.
2. S.15	Case-Hardening Steel 3 per cent. Nickel.	45	
S.17 -	Case-Hardening Steel 5 per cent. Nickel.	60–85	
S.18 -	High Tensile, ·35 per cent. Carbon.	100	
S.24 -	Key Steel; ·55 per cent. to ·70 per cent. Carbon.	55	S.2 can be used in lieu.
K.1–S.33, S.12–S.2	High Tensile Nickel Chrome Steels of varying composition.	55–70	

Mild Steels.

S.1,Pt.1	Medium Carbon Steel (Bright Drawn).	35–42	Rods, Bolts, Shafting. Not suitable for Welding, Forging, or Stamping.
S.1,Pt.2	Medium Carbon Steel (Hot Rolled).	35	Suitable for Welding, Forging, or Stamping.
S.3 -	Mild Steel Sheets (for Welding).	26	Suitable for Welding or Forging.
2.S.20 -	Tinned Steel Sheets.		Special: for use on aircraft (petrol tanks, etc.).
S.23 -	Medium Carbon Steel	35	Suitable for Welding or Forging. Can be used in lieu of S.1, Pt. 2.

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Mark.	Description.	Ultimate Tensile Strength Tons.	Uses.
S. 40–S. 43	Nickel Chrome or Carbon Steel, suitably rolled or heat treated.	40–75	

Steel Tubing:

T.1 -	Carbon, 3 per cent. hard-drawn and blued.	35	For heavily stressed parts. *Note.*—If heated to brazing heat, strength: 28 tons (ultimate).
T.21 -	Carbon, ·3 per cent. annealed.	28	For heavily stressed parts.
T6. -	Carbon, ·15 per cent. hard-drawn and blued.	30	For parts lightly stressed. *Note.*—If heated to brazing heat, strength: 20 tons (ultimate).
T.26 -	Carbon, ·15 per cent. half-hard.	20	For parts lightly stressed.

Tool Steels.

Mark.	Description.	Uses.
Tungsten Steels	Grade A. 18 per cent. Tungsten Grade B. 14 per cent. Tungsten	For machine tools—high speed operations.
Carbon Steels	Grade A. (High Temper) -	For turning milling slotting tools requiring lower cutting speed than Tungsten Steels. Also for manufacture of taps, dies, milling cutters, drills, etc.
	Grade B. (Medium Temper) -	Suitable for general engineering tools.
	Grade C. (Tough Temper) -	Suitable for wood cutting tools, shock tools, such as cold chisels, punches, etc.

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Note.—Carbon Tool Steels, Grades A B and C, will ultimately be replaced by five grades as below :—

Grade.	Temper No.	Description.	Suitable for	Carbon Content.
A.	1	Extra Hard	Small turning, planing and shaping tools.	1·3 to 1·4 %
	2	Very Hard	Large turning tools, small milling cutters, machine drills.	1·20 to 1·30%
	3	Hard	Taps, screwing dies, reamers, large cutters, drills, shear blades.	1·0 to 1·15%
B.	4	Medium Hard	Hand chisels, punches, springs. (This steel is weldable with care.)	·75 to ·90%
C.	5	Tough	Blacksmiths' tools, snaps, hammers, etc. (weldable).	·65 to ·75%

Forging Temperatures Nos. 1 and 2=800° Cent. (Full Cherry Red).
Forging Temperatures Nos. 3, 4 and 5=850° Cent. (Red).
Hardening Temperatures for each Temper=750° Cent. (Cherry Red).

Carbon Steel Lathe Tools.

Metal to be machined.	Suitable cutting speed, feet per minute.	Equivalent R.P.M. of a 1 in. bar. (To find suitable R.P.M. for work of other diameters, divide the figure in this column by the diameter of the work in inches.)	Suitable proportions for tool.		
			Clearance.	Tool Angle.	Top or Side Slope.
Cast steel	15 to 35	60 to 130	3°	75°	12°
Cast iron	20 to 40	75 to 150	5°	75°	10°
Mild steel	35 to 55	130 to 210	5°	70°	15°
Hard gun-metal or bronze	50 to 100	190 to 380	5°	80°	5°
Copper	50 to 100	190 to 380	5°	55°	30°
Brass	100 to 200	380 to 750	5°	85°	0°
Aluminium	100 to 200	380 to 750	5°	60°	25°

Notes.—(1) High speed steels, such as those containing tungsten, chromium or vanadium in addition to carbon, may be run at much higher speeds. Such steels are "self-hardening," and may be run with the point almost red hot. Carbon steels require re-hardening if the point becomes blue.

(2) The figures given above are a rough guide only. No hard and fast rules can be laid down. The most suitable cutting speed is dependent on :—(*a*) The quality of the metal to be machined, and (*b*) the depth of cut and rate at which the tool is fed to the work. Where the object is to remove as much metal as possible in a given time, the depth of cut and rate of feed should be increased, and the speeds given above may be exceeded. As a general rule it is best to start with a moderate speed and if the tool stands well try an increase of speed. With a good tool working under satisfactory conditions as to speed, feed and depth of cut, it will frequently occur that the rigidity of the lathe, of the rest and of the tool itself, or possibly the amount of power available, will become the controlling factors.

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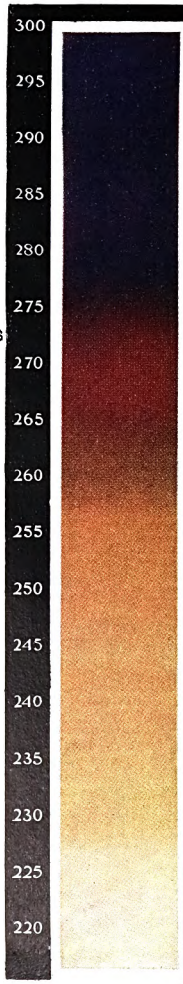
Steel Tempering Chart.



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Temper Colours.

Colour.	Degrees C.	Degrees F
Very light straw	220	428
Light straw	225	437
Pale straw	230	446
Straw	235	455
Dark straw	240	464
Dark yellow	245	473
Very dark yellow	250	482
Yellow brown	255	491
Yellowish brown	260	500
Reddish brown	265	509
Brown purple	270	518
Light purple	275	527
Full purple	280	536
Dark purple	285	545
Very dark purple	290	554
Full blue	295	563
Dark blue	300	572
Red	582	1080
Dark red	704	1300
Cherry red	788	1450
Bright cherry	982	1800
Light orange	1093	2000
White	1316	2400
Brilliant white	1399	2550
Dazzling white	1499	2730

The article is first made "glass hard" by heating to a bright cherry red (about 1650° F.) and quenching in cold water or salt solution.

It is then cleaned up with emery paper until the surface is bright enough to shew the temper colour.

Heat is gradually applied until the surface of the article attains the desired colour, when it is immediately quenched.

40. WORKSHOP TABLES.

Specific Gravity and Weights of Gases.

(Water = 1·0).

	Specific Gravity.	Weight of 1 Cubic Ft. (lbs.)
Carbonic acid	·00197	·123
Hydrogen	·0000895	·0056
Helium	·0001762	·0109
Nitrogen	·00125	·078
Oxygen	·00143	·089
Coal gas	·0004	·034
Air	·001293	·08072

Specific Gravity and Weights of Liquids.

(Water—1·0).

	Specific Gravity.	Weight of 1 Cubic In. (lbs.)
Acid, Acetic	1·10	·040
Acid, Hydrochloric	1·22	·044
Acid, Nitric	1·42	·051
Acid, Sulphuric	1·86	·067
Alcohol, absolute	·792	·028
Alcohol, proof	·916	·033
Benzene	·900	·033
Ether	·716	·026

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SIDE CUTTING TOOL

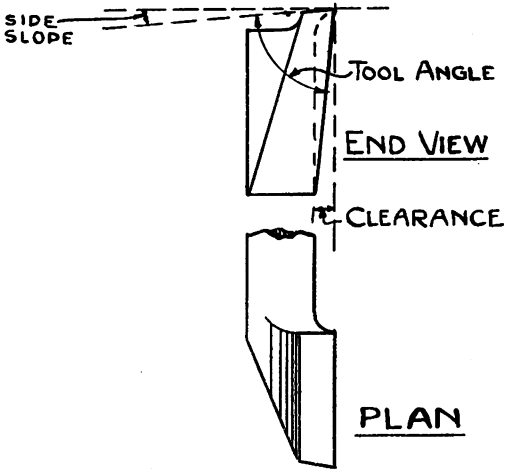
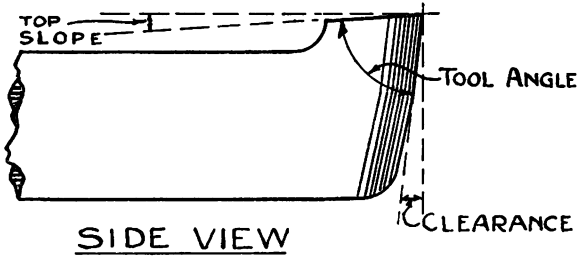


FIG. 101.

NOSE CUTTING TOOL



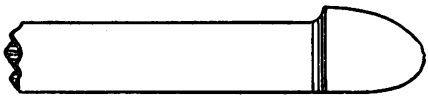


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FIG. 102.

Specific Gravity and Weights of Liquids—*continued.*

(Water—1·0).

	Specific Gravity.	Weight of 1 Cubic In. (lbs.)
Glycerin	1·260	·046
Oil, lubricating, mineral	·900	·0326
Oil, lubricating, castor	·963	·0348
Oil, linseed	·95–·97	·0344–·0351
Oil, whale	·94	·034
Petroleum	·886–·938	·032–·034
Water, fresh	1·00	·03616
Water, sea	1·026	·0370
Petrol	·72–·78	·026–·028
Paraffin	·87	·032

Specific Gravity and Weights of Metals.

(Water—1·0).

Metal.	Specific Gravity.	Weight of 1 Cubic In. (lbs.)
Aluminium cast	2·56	·0927
Aluminium, wrought	2·67	·0968
Aluminium, bronze	7·68	·275
Antimony	6·71	·242
Babbit metal	7·31	·263
Brass, cast	8·10	·293
Brass, 75 Copper, 25 Zinc, sheet	8·45	·305
Brass, 66 Copper, 34 Zinc, yellow	8·30	·300
Bronze, 84 Copper, 16 Tin, Gun-metal	8·56	·310
Bronze, 81 Copper, 19 Tin, Gun-metal	8·46	·305
Copper, sheet	8·805	·318
Copper, hammered	8·917	·322
German silver	8·28	·300
Gold	19·245	·695
Iron, wrought :—		
Least and greatest density	7·47–7·808	·270–·282
Average	7·698	·278
Iron, cast :—		
Least and greatest density	6·9–7·5	·250–·271
Average	7·217	·261
Lead	11·212–11·418	·408–·412
Manganese	8·00	·289
Mercury	13·596	·491
Nickel, hammered	8·67	·312
Nickel, cast	8·28	·300
Phosphor Bronze, cast	8·60	·310
Phosphor Bronze, drawn or rolled	8·72	·316
Platinum	21·522	·778
Plumbago	2·24	·081
Silver	10·505	·380
Steel :—		
Least and greatest densities	7·729–7·904	·278–·285
Average	7·852	·283
Tin	7·409	·268
Tungsten	18·77	·677
Zinc, sheet	7·20	·260
Zinc, cast	6·86	·248

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Specific Gravity and Weights of Miscellaneous Solids.

(Water — 1·0).

Substance.	Specific Gravity.	Weight of 1 Cubic In. (lbs.)
Alabaster	2·5–2·88	·0904–·108
Alum	1·71	·062
Asbestos	2·10–2·80	·076–·101
Brick	1·87–1·90	·068–·069
Stourbridge Fire	2·30	·083
Calcium	1·58	·057
Cement	2·72–3·05	·0984–·109
Chalk	1·8 – 2·7	·065–·0975
Charcoal	·36	·013
Chloride of Lime	2·22	·081
Clay	2·0	·072
Cloth	·277–·36	·01–·013
Coal	1·37	·0495
Coke	·5	·0181
Concrete	2·0	·072
Ebonite	1·38	·05
Fibre	1·39	·051
Flint	2·59	·0935
Fluor-Spar	3·15	·114
Glass, window	2·65	·090
Granite	2·5–2·75	·091–·100
Graphite	1·8–2·35	·065–·085
Gum resin	1·15	·0415
Gutta-percha	·97–·98	·035–·0355
Hematite	4·9	·177
Ivory	1·87	·065
Marble	2·65	·096
Mica	2·78–3·15	·1–·114
Pitch	1·07	·0386
Porcelain	2·15–2·35	·078–·085
Presspahn	1·25	·045
Quartz	2·5	·090
Resin	1·08	·039
Retort Carbon	1·9	·069
Rubber :—		
Pure	·83	·03
For Jointing	2·21–2·77	·08–·10
Sal-ammoniac	1·46	·53
Salt	2·14	·077
Sand-stone	2·3	·083
Slate	2·8	·102
Soapstone	2·6	·094
Sugar	1·6	·058
Sulphur	1·98	·072
Tile	1·4–2·00	·051–·0725
Vulcanite	1·52	·55
Vulcanised fibre	1·28	·0464
Wax	·97	·0351
Wood :—		
Ash	·69–·76	·025–·027
Bamboo	·40	·015
Beech	·75	·0271
Birch	·74	·0268
Box	1·30	·047
Cedar, West Indian	·74	·026
Cedar, American	·55	·020
Cedar, Lebanon	·48	·017
Chestnut	·60	·022
Cork	·24	·0087

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Specific Gravity and Weights of Miscellaneous Solids—*continued.*

(Water — 1·0).

Substance.	Specific Gravity.	Weight of 1 Cubic In. (lbs.)
Ebony	1·19	·043
Elm, English	·58	·021
Elm, Canadian	·72	·026
Fir	·56	·0203
Fir, American White Spruce	·54	·019
Fir, California Spruce	·48	·017
Fir, Norway Spruce	·50	·018
Fir, Riga	·75	·027
Fir, Memel	·54	·019
Fir, Scotch	·52	·018
Hickory	·69	·025
Hornbeam	·76	·027
Ironwood	1·20	·0435
Lignum Vitae	1·35	·049
Mahogany, Honduras	·56	·02
Mahogany, Spanish	·85	·031
Maple	·75	·0272
Oak, African	·98	·035
Oak, American, red	·85	·03
Oak, American, white	·77	·028
Oak, English	·65–·93	·025–·034
Pine, red	·57–·65	·021–·024
Pine, white	·43–·55	·015–·02
Pine, Memel	·55	·02
Pine, Riga	·46	·017
Pine, Pitch	·65	·023
Poplar	·36	·013
Sycamore	·60	·022
Teak	·80	·029
Walnut	·67	·024

Properties of Metals.

Metal.	Specific heat, Water = 1·00. At 32° Fahr.	Specific heat, Water = 1·00. At Melting Point.	Coefficient of linear expansion per ° Fahr.	Relative Heat Conductivity. Silver = 100.	Relative Electrical Conductivity. Silver = 100.	Melting Point 0° Fahr.
Aluminium	·022	·31	·000036	35	57	1200
Brass	·092	—	·000034	—	—	1700–1850
Copper	·094	·133	·000034	92	94	1980
Gold	·031	·036	·000027	70	67	1950
Iron	·112	·21	·000018	16	17	2300
	·113	·22	·000023			2900
Lead	·029	·042	·000050	8·5	7·2	620
Nickel	·108	—	·000021	14	20·5	2600
Platinum	·032	·053	·000016	17	13·5	3200
Silver	·056	·078	·000036	100	100	1760
Tin	·056	·064	·000038	15·2	11·3	450
Zinc	·090	·128	·000052	26·3	25·5	785

Notes.—Specific Heat is not constant but increases with rise of temperature.

COEFFICIENT OF SUPERFICIAL EXPANSION is twice that of linear and *CUBICAL EXPANSION* three times that of linear.

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Relative Value of Heat Non-Conductors.

Wool, loose	300
Hair or Wool Felt	100
Charcoal (Cork)	80
Straw rope	75
Rice chaff	75
Silicate cotton (Slag wool)	70
Cork	70
Sawdust	65
Charcoal (Wood)	65
Paper	60
Loam (dry and open)	55
Wood (cross grain)	50
Coal ashes	38
Asbestos	36
Plaster of Paris	34
Coke (lump)	27
Sand	17
Air space (undivided)	15

Note.—Figures vary considerably. Those given should be considered approximate only.

Relative Value of Electrical Insulators.

Substance.	Specific resistance per c.cm. Ohms.
Glass	$16700000 \times 10^{\cdot}$
Porcelain	$540000 \times 10^{\cdot}$
Paraffin (solid)	$34000 \times 10^{\cdot}$
Rubber (hard)	$28000 \times 10^{\cdot}$
Gutta Percha	$449 \times 10^{\cdot}$
Mica	$84 \times 10^{\cdot}$

Note.—Specific Resistance is the resistance in ohms between the opposite faces of a cube of 1 cm.

Coefficients of Friction.

The frictional resistance of one body sliding on another is generally proportional to the load or force pressing the two bodies together. The coefficient of friction given below indicates the relative proportion of this load equivalent to the frictional resistance.

The coefficients should be regarded as approximate only, the resistance varying considerably according to the condition of the surfaces in contact which are regarded as being smooth.

Metals on metals, well lubricated	0·03 to 0·08
Cast-iron on cast-iron, wrought-iron or brass	0·15 to 0·2
Cast-iron on copper	0·18 to 0·2
Cast-iron on steel	0·2 to 0·3
Brass on steel or wrought-iron	0·15 to 0·17
Wrought-iron on wrought-iron	0·14
Steel on steel	0·14
Dry leather on metals	0·5 to 0·6
Wet leather on metals	0·35 to 0·4
Greasy leather on metals	0·2 to 0·23
Oily leather on metals	0·15 to 0·18
Oak on copper or wrought-iron, dry	0·55 to 0·65
Oak on cast-iron, dry	0·45 to 0·5
Elm on cast-iron, dry	0·2 to 0·25
Pine on steel or brass, dry	0·16 to 0·19
Ferodo fabric on metal	0·3 to 0·4

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Water, Petrol, Oil.

Useful Data.

1 Cubic Foot = 6·228 Gallons.
1 Gallon = ·161 Cubic Foot.

The weight of Fresh Water is to that of Sea Water as 1 is to 1·026.

	Water.	Petrol.		Oil.	
		Aviation.	M.T.	Mineral.	Castor.
Specific Gravity - -	1·00	·722	·735	·900	·963
1 Gallon=(lbs.) - -	10	7·2	7·35	9·00	9·63
Specific Gravity - -	1·00	·722	·735	·900	·963
1 Ton = (galls.) - -	224	311	305	248	233
1 Ton = (c. ft.) - -	36	49·8	50	40	37·4

Weight of Sheet Metal.

(POUNDS PER SQUARE FOOT.)

S.W.G. of Sheet.	Thickness in Inches.	Aluminium.	Brass.	Copper.	Mild Steel.
0	0·324	4·50	14·44	14·91	13·20
1	0·300	4·17	13·38	13·82	12·22
2	0·276	3·84	12·32	12·74	11·24
3	0·252	3·51	11·26	11·60	10·26
4	0·232	3·08	10·36	10·70	9·45
5	0·212	2·81	9·47	9·78	8·63
6	0·192	2·54	8·57	8·84	7·82
7	0·176	2·34	7·85	8·11	7·17
8	0·160	2·12	7·13	7·38	6·51
9	0·144	1·91	6·41	6·62	5·87
10	0·128	1·70	5·71	5·90	5·21
11	0·116	1·54	5·18	5·33	4·72
12	0·104	1·38	4·64	4·80	4·24
14	0·080	1·06	3·57	3·68	3·26
16	0·064	0·849	2·86	2·95	2·61
18	0·048	0·637	2·15	2·21	1·96
20	0·036	0·477	1·61	1·66	1·47
22	0·028	0·371	1·25	1·29	1·142
24	0·022	0·292	0·982	1·015	0·897
26	0·018	0·239	0·804	0·830	0·735
28	0·014	0·186	0·625	0·644	0·571
30	0·012	0·159	0·536	0·552	0·490
32	0·010	0·133	0·447	0·461	0·408
34	0·009	0·120	0·402	0·415	0·367
36	0·007	0·093	0·313	0·322	0·286
38	0·006	0·079	0·268	0·276	0·245
40	0·004	0·053	0·179	0·184	0·164

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CONVERSION FACTORS.

LENGTH.

	Inches.	Feet.	Yards.	Cm.	Metres
1. in.		·083	·0276	2·540	·0254
1. ft.	12·		·3	30·48	·3048
1. yd.	36·	3·		91·44	·9144
1. cm.	·3937	·03281	·01094		·01
1. m.	39·37	3·281	1·094	100·0	

AREA

	Sq. Inches.	Sq. Feet.	Sq. Yards.	Sq. Cm.	Sq. M.
1. sq. in.		·006944	·0007716	6·452	·0006452
1. sq. ft.	144		·1	929·0	·09290
1. sq. yd.	1296	9		8361·	·8361
1. sq. cm.	·1550	·001076	·0001196		·0001
1. sq. m.	1550·	10·76	1·196	10,000	

VELOCITY

	Feet / Sec.	Ft / Min.	M.P.H.	Knots	Cms / Sec.	Metres / Sec.	Km / Hr.
1. Foot / Sec.		60	·68182	·592105	30·4801	·304801	1·0973
1. Foot / Min.	·016667		·011364	·0098684	·50800	·00508	·018788
1. Mile / Hr.	1·4667	88		·86842	44·704	·44704	1·60935
1. Knot	1·6889	101·33	1·1515		51·478	·51478	1·8532
1. cm. / Sec.	·032808	1·9685	·022369	·019426		·01	·036
1. m. / Sec.	3·2808	196·85	2·2369	·9426	100		3·60
1. Km. / Hr.	·91134	54·68	·62137	·53961	·27778	·27778	

WEIGHT & VOLUME OF WATER

	Lbs.	Tons	Grm. or C.c. cm. of W.	Cu Inches	C. Feet.	Litres (c. Decimetre)	Galls
1. lb.		$10^{-4} \times 4464$	453·6	27·68	·016017	·4536	·1
1. Ton.	2240		1,016,047	62000	35·88	1016·	224
1. grm. or cu. cm.	·002205	$10^{-7} \times 9·842$		·06102	$10^{-5} \times 3·531$	·001	·00022
1. cu. inch of water	·03613	$10^{-5} \times 1·6178$	16·388		$10^{-4} \times 5·790$	·01639	
1. cu. foot of water	62·43	·02787	28317	1728		28·32	
1. litre of water	2·2046	$10^{-4} \times 9·842$	1000	61·02	·03531		
1. gallon of water	10	·004464	4546				

FIG. 103.

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ENERGY & MOMENTS.

	FEET × LBS. WT	INCHES × LBS. WT	INCHES × TONS WT	FEET × TONS WT	CMS × GMS WT	METRES × KG. WT	FOOT POUNDALS	CM × DYNES OR ERGS	JOULES	CALORIES OR DI.GM.WATER FROM 0° TO 100°C	B.T.U. OR LB. WATER FROM 32° TO 212°F.
1 FT. × LB. WT		12	.005357	10^{-4} 4·4643	13825	·13825	32·185 (THIS WAS THE VALUE OF g)	10^{7} × 1·3563	1·3563	·32416	·0012863
1 INCH × LB. WT	·083		10^{-6} 4·4643	10^{-5} × 3·720	1152·1	·011521	2·6821	10^{6} × 1·3025	·11302	·027013	10^{-4} × 1·072
1 INCH × TON WT	186·6	2240		·083	10^{6} × 2·58075	25·808	6007·8	10^{9} × 2·5317	253·17	60·51	·24012
1 FOOT × TON WT	2240	26880	12		10^{7} × 3·0969	309·69	72094	10^{10} × 3·038	3038	7261	2·8814
1 CM × GM. WT	10^{-5} × 7·233	10^{-4} × 86706	10^{-7} × 3·875	10^{-8} × 3·229		·00001	·002328	981	10^{-3} × 9·81	10^{-5} × 2·3446	10^{-8} × 9·304
1 MET × KG. WT	7·233	86·796	·038749	·003229.	10^{5}		232·8	10^{5} × 981	9·81	2·3446	·009304
1 FT POUNDAL	·03107	·37285	10^{-3} × 1·6645	10^{-4} × 1·3871	429·57	·0042957		421400	·04214	·0100717	10^{-3} × 3·9987
1 CM DYNE OR ERG.	10^{-8} × 7·373	10^{-7} × 8·848	10^{-10} × 3·950	10^{-11} × 3·2916	·0010194	10^{-8} × 1·0194	10^{-6} × 2·373		10^{-7}	10^{-8} × 2·3901	10^{-11} × 9·484
1 JOULE	·7373	8·8477	10^{-3} × 3·950	10^{-4} × 3·2916	10194	10194	23·73	10^{7}		·23901	10^{-4} × 9·484
1 CALORIE	3·0849	37·02	·016526	10^{-3} × 1·3772	42650	·4265	99·29	10^{7} × 4·184	4·184		·003968
1 B.T.U.	777·4	9329	4·1645	·34704	10^{2} × 1·0748	107·48	25020	10^{10} × 1·0543	1054·3	252.	

NOTE: B.T.U. = BRITISH THERMAL UNIT
1 BOARD OF TRADE UNIT (ELECTR.) = 3·6 × 10^{6} JOULES OR WATT SECS: 1 KILOWATT HOUR)

POWER

	ERGS PER SEC	CM. GM./SECS	WATTS	FT. LBS./SEC	H.P.	FORCES DE CHEVAL	KILOWATTS
1 ERG PER SEC		·0010194	10^{-7}	10^{-8} × 7·373	10^{-10} × 1·3406	10^{-10} × 1·3592	10^{-10}
1 CM. GM./SEC	981		10^{-5} × 9·81	10^{-5} × 7·233	10^{-7} × 1·315	10^{-7} × 1·3333	10^{-8} × 9·81
1 WATT	10^{7}	10194		·7373	·0013406	·0013592	·001
1 FT. LB./SEC	10^{-7} × 1·3563	13825	1·3563		·0018182	·0018434	·0013563
1 H.P.	10^{-9} × 74595	10^{-6} × 7·604	745·95	550		1·0139	·74595
1 FORCE DE CHEVAL	10^{-9} × 7·3575	10^{-6} × 7·5	735·80	542·48	·9863		·73575
1 KILO-WATT.	10^{10}	10^{3} × 1·0194	1000	737·30	1·3406	1·3592	

PRESSURE & STRESS

	LBS/SQ. IN.	LBS/SQ. FT.	TONS/SQ. IN.	KM./SQ. M. OR MM. OF WATER	KM./SQ. CM.	DYNES/SQ. CM.	FEET OF WATER
1 LB PER SQ. IN		144	10^{-4} × 4·4643	703·06	·070306	68971·0	2·3067
1 LB PER SQ. FOOT	10^{-3} × 6·9443		10^{-6} × 3·1002	4·883	10^{-4} × 4·883	478·96	·01602
1 TON PER SQ. IN.	224·0	322560		10^{3} × 1·575	157·5	10^{3} × 1·5448	5167·0
1 KM./SQ. M. OR MM. OF WATER	·0014224	·20482	10^{-6} × 6·350		·0001	98·10	·003281
1 KM. PER SQ. CM.	14·224	2048·2	·006350	10000		981000	32·81
1 DYNE PER SQ. CM.	10^{-5} × 1·4499	·0020878	10^{-9} × 6·473	·010193	10^{-6} × 1·0193		10^{-5} × 3·3445
1 FOOT OF WATER	·43352	62·43	10^{-3} × 9·353	304·8	·03048	29900·	

NOTE: 10^{+4} = 100,000, 10^{-4} = ·0010 AND IS SO WRITTEN FOR BREVITY.

FIG. 104.

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Weights of Flat Bar Iron.

Pounds per Lineal Foot.

Breadth in Inches.	Thickness in Inches.																	
	¼	5/16	⅜	7/16	½	9/16	⅝	¾	1	1⅛	1¼	1⅜	1½	1⅝	1¾	1⅞	2	2¼
1	0·83	1·04	1·25	1·46	1·67	2·08	2·50	2·92	3·33	—	—	—	—	—	—	—	—	—
1⅛	0·94	1·17	1·41	1·64	1·88	2·34	2·81	3·28	3·75	—	—	—	—	—	—	—	—	—
1¼	1·04	1·30	1·55	1·82	2·08	2·60	3·13	3·65	4·17	4·69	—	—	—	—	—	—	—	—
1⅜	1·15	1·43	1·72	2·01	2·29	2·87	3·44	4·01	4·58	5·16	5·73	—	—	—	—	—	—	—
1½	1·25	1·56	1·88	2·19	2·50	3·13	3·75	4·38	5·00	5·63	6·25	6·88	—	—	—	—	—	—
1⅝	1·35	1·69	2·03	2·37	2·71	3·39	4·06	4·74	5·42	6·09	6·77	7·45	8·13	—	—	—	—	—
1¾	1·46	1·82	2·19	2·55	2·92	3·65	4·38	5·10	5·83	6·56	7·29	8·02	8·75	9·48	—	—	—	—
1⅞	1·56	1·95	2·34	2·73	3·13	3·91	4·69	6·47	6·25	7·03	8·71	8·59	9·38	10·16	10·94	—	—	—
2	1·67	2·08	2·50	2·92	3·33	4·17	5·00	5·83	6·67	7·50	8·33	9·17	10·00	10·83	11·67	12·50	—	—
2¼	1·77	2·21	2·66	3·10	3·54	4·43	5·31	6·20	7·08	7·97	8·85	9·74	10·63	11·51	12·40	13·28	14·17	—
2½	1·88	2·34	2·81	3·28	3·75	4·69	5·63	6·56	7·50	8·44	9·38	10·31	11·25	12·19	13·13	14·06	15·00	15·94
2⅝	1·98	2·47	2·97	3·46	3·96	4·95	5·94	6·93	7·92	8·91	9·90	10·89	11–88	12·87	13·85	14·84	15·83	16·82
2¾	2·08	2·60	3·13	3·65	4·17	5·21	6·25	7·29	8·33	9·38	10·42	11·46	12·50	13·54	14·58	15·63	16·67	17·71
2⅞	2·19	2·73	3·28	3·83	4·38	5·47	6·56	7·66	8·75	9·84	10·94	12·03	13·13	14·22	15·31	16·41	17·60	18·59
3	2·29	2·87	3·44	4·01	4·58	5·73	6·88	8·02	9·17	10·31	11·46	12·60	13·75	14·90	16·04	17·19	18·33	19·48
3⅛	2·40	3·00	3·59	4·19	4·79	5·99	7·19	8·39	9·58	10·78	11·98	13·18	14·38	15·57	16·77	17·97	19·17	20·36
3¼	2·50	3·13	3·75	4·38	5·00	6·25	7·50	8·75	10·00	11·25	12·50	13·75	15·00	16·25	17·50	18·75	20·00	21·25
3⅜	2·71	3·39	4·06	4·74	5·42	6·77	8·13	9·48	10·83	12·19	13·54	14·90	16·25	17·60	18·96	20·31	21·67	23·02
3½	2·92	3·65	4·38	5·10	5·83	7·29	8–75	10·21	11·67	13·13	14·58	16·04	17·50	18·96	20·42	21·88	23·33	24·79
3⅝	3·13	3·91	4·69	5·47	6·25	7·81	9·38	10·94	12·50	14·06	15·63	17·19	18·75	20·31	21·88	23·44	25·00	26·56
4	3·33	4·17	5·00	5·83	6·67	8·33	10·00	11·67	13·33	15·00	16·67	18·33	20·00	21·67	23·33	25·00	26·67	28·33
4¼	3·54	4·43	5·31	6·20	7·08	8·85	10·63	12·40	14·17	15·94	17·71	19·48	21·25	23·02	24·79	26·56	28·33	30·10
4½	3·75	4·69	5·63	6·56	7·50	9·38	11·25	13·13	15·00	16·88	18·75	20·63	22·50	24·38	26·25	28·13	30·00	31·88
4¾	3·96	4·95	5·94	6·93	7·92	9·90	11·88	13·85	15·83	17·81	19·79	21·77	23·75	25·73	27·71	29·69	31·67	33·65
5	4·17	5·21	6·25	7·29	8·33	10·42	12·50	14·58	16·67	18·75	20·83	22·92	25·00	27·08	29·17	31·25	33·33	35·42
5¼	4·38	5·47	6·56	7·66	8·75	10·94	13·13	15·31	17·50	19·69	21·88	24·06	26·25	28·44	30·63	32·81	35·00	37·19
5½	4·58	5·73	6·88	8·02	9·17	11·46	13·75	16·04	18·33	20·63	22·92	25·21	27·50	29·79	32·08	34·38	36·67	38·96
5¾	4·79	5·99	7·19	8·39	9·58	11·98	14·38	16·77	19·17	21·56	23·96	26·35	28·75	31·15	33·54	35·94	38·33	40·73
6	5·00	6·25	7·50	8·75	10·00	12·98	15·00	17·50	20·00	22·50	25·00	27·50	30·00	32·50	35·00	37·50	40·00	42·50

Note.—To ascertain weight of other metal bar divide above by 7·69 and multiply by specific gravity of metal required.

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Standard Screw Threads.

B.A. No.	B.S.F.	Whitworth.	International (Metric).	Full Dia. Inches.	Full Dia. M/m.	Threads per Inch.	Core Dia. Inches.	Core Dia. M/m.
—	—	1/16	—	·062	1·58	60	·0412	1·045
10	—	—	—	·067	1·70	72·6	·0504	1·28
8	—	—	—	·0870	2·209	59·1	·0657	1·68
—	—	5/64	—	·0937	2·379	48	·0671	1·72
6	—	—	—	·110	2·794	47·9	·0849	2·16
—	—	—	3	·1181	3·000	46·19	·0899	2·28
—	—	3/32	—	·1250	3·175	40	·0930	2·36
—	—	—	3·5	·1378	3·5	46·19	·1097	2·78
4	—	—	—	·1420	3·606	38·5	·1108	2·81
—	—	7/64	—	·1562	3·967	32·	·1162	2·95
—	—	—	4	·1575	4	36·28	·1217	3·085
—	—	—	4·5	·1772	4·5	36·28	·1414	3·59
2	—	—	—	·1850	4·699	31·4	·1467	3·72
—	—	1/8	—	·1875	4·762	24·	·1342	3·41
—	—	—	5	·1968	5·	29·88	·1534	3·9
—	—	9/64	—	·2187	5·555	24	·1654	4·2
0	—	—	—	·2360	5·994	25·4	·1887	4·8
—	—	—	6	·2362	6·000	24·4	·1859	4·72
—	—	5/32	—	·25	6·349	20	·1860	4·72
—	—	—	—	·25	6·349	26	·2007	5·1
—	1/4	—	7	·275	7·000	35·4	·2244	5·65
—	—	11/64	—	·281	7·143	20·	·2172	5·52
—	9/32	—	—	·281	7·143	26	·2320	5·89
—	—	3/16	—	·312	7·937	18	·2414	6·12
—	5/16	—	—	·312	7·937	22	·2543	6·46
—	—	—	8	·315	8·	20·32	·2510	6·38
—	—	—	9	·354	9	20·32	·2904	7·37
—	—	13/64	—	·375	9·524	16	·2950	7·5
—	3/8	—	—	·375	9·524	20	·3110	7·9
—	—	—	10	·393	10	16·94	·3170	8·05
—	—	—	11	·433	11	16·94	·3563	9·06
—	—	7/16	—	·437	11·112	14	·3460	8·78
—	7/16	—	—	·437	11·112	18	·3664	9·30
—	—	—	12	·472	12	14·51	·3829	9·73
—	—	1/2	—	·5	12·699	12	·3933	10·00
—	1/2	—	—	·5	12·699	16	·4200	10·67
—	—	9/16	—	·5625	14·29	12	·4558	11·62
—	—	5/8	—	·625	15·88	11	·5086	12·9
—	—	11/16	—	·75	19·05	10	·6219	15·8
—	—	3/4	—	·875	22·2	9	·7327	18·6
—	—	1	—	1·	25·4	8	·8399	21·5

Standard Wire Gauge in Inches and Millimetres.

S.W.G. No.	Diameter in Inches.	Diameter in Millimetres.	S.W.G. No.	Diameter in Inches.	Diameter in Millimetres.
4/0	·400	10·155	1	·300	7·617
3/0	·372	9·446	2	·275	7·008
2/0	·348	8·836	3	·252	6·34
0	·324	8·226	4	·232	5·891

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Standard Wire Gauge in Inches and Millimetres—*continued.*

S.W.G. No.	Diameter in Inches.	Diameter in Millimetres.	S.W.G. No.	Diameter in Inches.	Diameter in Millimetres.
5	·212	5·383	28	·0148	0·376
6	·192	4·875	29	·0136	0·345
7	·176	4·469	30	·0124	0·315
8	·160	4·062	31	·0116	0·294
9	·144	3·656	32	·0108	0·274
10	128	3·250	33	·0100	0·254
11	·116	2·945	34	·0092	0·234
12	·104	2·6405	35	·0084	0·213
13	·092	2·336	36	·0076	0·210
14	·080	2·031	37	·0068	0·173
15	·072	1·828	38	·0060	0·152
16	·064	1·625	39	·0052	0·132
17	·056	1·422	40	·0048	0·122
18	·048	1·218	41	·0044	0·112
19	·040	1·015	42	·0040	0·101
20	·036	0·914	43	·0036	0·091
21	·032	0·813	44	·0032	0·081
22	·028	0·711	45	·0028	0·071
23	·024	0·61	46	·0024	0·061
24	·022	0·559	47	·0029	0·050
25	·020	0·508	48	·0016	0·040
26	·018	0·457	49	·0012	0·030
27	·0164	0·416	50	·0010	0·023

Twist Drills.

Comparative Table of Lancashire or Stubs' Wire Gauge, English and Metric Drills.

Lancashire Wire Gauge.	Inches.	Millimetres.	Decimal Inches.	Lancashire Wire Gauge.	Inches.	Millimetres.	Decimal Inches.
—	1/32	—	·031	45	—	—	·081
60	—	1	·039	44	—	—	·085
59	—	—	·040	43	—	—	·088
58	—	—	·041	42	—	—	·092
57	—	—	·042	—	3/32	—	·093
56	—	—	·045	41	—	—	·095
—	3/64	—	·046	40	—	—	·097
55	—	—	·050	39	—	—	·099
54	—	—	·055	38	—	—	·101
53	—	—	·058	37	—	—	·103
—	1/16	—	·062	36	—	—	·106
52	—	—	·063	35	—	—	·108
51	—	—	·066	—	7/64	—	·109
50	—	—	·069	34	—	—	·110
49	—	—	·072	33	—	—	·112
48	—	—	·075	32	—	—	·115
47	—	—	·077	—	—	3	·118
—	5/64	—	·078	31	—	—	·120
46	—	2	·079	—	1/8	—	·125

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Twist Drills—*continued.*

Comparative Table of Lancashire or Stubs' Wire Gauge, English and Metric Drills—continued.

Lancashire Wire Gauge.	Inches.	Millimetres.	Decimal Inches.	Lancashire Wire Gauge.	Inches.	Millimetres.	Decimal Inches.
30	—	—	·127	—	21/64	—	·328
29	—	—	·134	—	11/32	—	·343
...	9/64	—	·140	—	—	9	·354
28	—	—	·139	—	23/64	—	·359
27	—	—	·143	—	3/8	—	·375
26	—	—	·146	—	25/64	—	·390
25	—	—	·148	—	—	10	·394
24	—	—	·151	—	13/32	—	·406
23	—	—	·153	—	27/64	—	·421
22	—	—	·155	—	—	11	·433
—	5/32	—	·156	—	7/16	—	·437
21	—	4	·157	—	29/64	—	·453
20	—	—	·161	—	15/32	—	·468
19	—	—	·164	—	—	12	·472
18	—	—	·168	—	31/64	—	·484
—	11/64	—	·171	—	1/2	—	·500
17	—	—	·172	—	—	13	·512
16	—	—	·175	—	17/32	—	·531
15	—	—	·178	—	—	14	·551
14	—	—	·180	—	9/16	—	·562
13	—	—	·182	—	—	15	·591
12	—	—	·185	—	19/32	—	·593
—	3/16	—	·187	—	5/8	—	·625
11	—	—	·188	—	—	16	·630
10	—	—	·191	—	41/64	—	·656
9	—	—	·194	—	—	17	·669
8	—	5	·197	—	11/16	—	·687
7	—	—	·199	—	—	18	·709
6	—	—	·201	—	23/32	—	·718
—	13/64	—	·203	—	—	19	·748
5	—	—	·204	—	3/4	—	·750
4	4	—	·207	—	49/64	—	·781
3	—	—	·212	—	—	20	·787
—	7/32	—	·218	—	13/16	—	·812
2	—	—	·219	—	—	21	·827
1	—	—	·227	—	27/32	—	·843
—	15/64	—	·234	—	—	22	·866
—	—	6	·236	—	7/8	—	·875
—	1/4	—	·250	—	57/64	23	·906
—	17/64	—	·265	—	15/16	—	·937
—	—	7	·276	—	—	24	·945
—	9/32	—	·281	—	31/32	—	·968
—	19/64	—	·296	—	—	25	·984
—	5/16	—	·312	—	—	—	1·000
—	—	8	·315				

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A.—Italian Hemp.
Specification F.14.

Ref. No.	Circumference.	Breaking Strain.	Safe working load. (⅓ Breaking Strain).	Approximate weight per 100 fathoms.
		lbs.	lbs.	lbs.
29	½ in.	476	95	8
30	¾ in.	1008	200	15
31	1 in.	1344	270	18
32	1¼ ins.	1680	335	36
33	1½ ins.	2352	470	44
34	2 ins.	4144	830	72
35	2½ ins.	6496	1300	132
36	3 ins.	9408	1900	182

B.—Manilla Hawser White.
Specification F.13.

Ref. No.	Circumference.	Breaking Strain.	Safe working load. (⅓ Breaking Strain).	Approximate weight per 122 fathoms.
		lbs.	lbs.	lbs.
46	½ in.	392	80	10
47	¾ in.	728	145	20
48	1 in.	952	190	26
49	1¼ ins.	1344	270	33½
50	1½ ins.	2072	415	53
52	2 ins.	3472	695	86
53	2½ ins.	5376	1075	134
54	3 ins.	7840	1570	192

Note.—Tarred rope is weaker than untarred and about 20 per cent. heavier.

C.—Hemp Hawser Tarred.

Ref. No.	Circumference.	Breaking Strain.	Safe working load. (⅓ Breaking Strain).	Approximate weight per 122 fathoms.
		lbs.	lbs.	lbs.
12	½ in.	364	75	12½
14	¾ in.	372	135	25
15	1 in.	856	170	31½
16	1¼ ins.	1736	345	67
17	2 ins.	2800	560	109
18	2½ ins.	4480	900	169
19	3 ins.	6272	1250	241
20	3½ ins.	8500	1700	329
21	5 ins.	17400	3500	665

Note.—The breaking strains and safe working loads given are for *new ropes.*

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For used ropes in good condition a lower figure should be taken.

Safe working load for field purposes (ropes in good condition) may be taken as :—

C^2 cwts. for ordinary hemp.
C^3 cwts. for Manilla.
C^3 cwts. for Italian hemp.
C = Circumference in inches.

Wire Steel Flexible.

Specification 2, W.2.

Ref. No.	Diameter.	Circumference.	Breaking Strain.	Safe Working Load ($\frac{1}{5}$ Breaking Strain).	Approximate weight per 100 feet.
			cwts.	cwts.	lbs.
3446	·075	·235	5	1	1·0
3447	·115	·363	10	2	2·0
3448	·137	·430	15	3	3·2
3449	·150	·470	20	4	3·8
3450	·168	·528	25	5	5·0
3451	·195	·614	35	7	6·4
3452	·228	·717	45	9	9·0
3453	·262	·825	60	12	11·7
3454	·270	·850	70	14	12·4
3455	·305	·961	80	16	15·1
3456	·349	1·095	100	20	19·6
3457	·378	1·188	120	24	22·5
3458	·388	1·22	140	28	25·5
3459	·418	1·315	160	33	28·9

Wire Steel Rope.

Ref. No.	Diameter.	Circumference.	Breaking Strain.	Safe Working Load ($\frac{1}{5}$ Breaking Strain).	Approximate weight per 100 fathoms.
			cwts.	cwts.	lbs.
1072	·12	$\frac{3}{8}$ in.	8	$1\frac{1}{2}$	16
1073	·16	$\frac{1}{2}$ in.	14	$2\frac{3}{4}$	26
1074	·20	$\frac{5}{8}$ in.	21	4	40
1076	·24	$\frac{3}{4}$ in.	32	6	60
1077	·314	1 in.	40	8	110
1078	·40	$1\frac{1}{4}$ ins.	62	12	175
1079	·48	$1\frac{1}{2}$ ins.	88	17	250
1080	·64	2 ins.	160	32	400
1081	·8	$2\frac{1}{2}$ ins.	246	49	640
1082	1·12	$3\frac{1}{2}$ ins.	488	97	1300

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Current Carrying Capacity of Lighting Wires.

Ref. No.	Type.	No. of Cores.	Size of Conductors.	Capacity (amps).	Uses.
174	Vircom 3	1	1 × ·044	3·5	Lighting and power other than in conduit.
175	,, 6	1	3 × ·036	6·4	
176	,, 12	1	7 × ·036	12·9	
177	,, 17	1	7 × ·044	17·9	
178	,, 33	1	7 × ·064	33·1	
179	,, 54	1	19 × ·052	54	
180	,, 75	1	19 × ·064	75	
181	,, 91	1	19 × ·072	91	
182	,, 113	1	19 × ·082	113	
	Flexible Wire.				
193	Liflex 4	2	23 × ·0076	4	For pendant lights.
194	,, 7	2	40 × ·0076	7	

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CHAPTER VIII.

TRANSPORTATION.

41. TRANSPORT BY RAIL.

General Instructions.

1. When a C.O. unit has to make arrangements for the movement of personnel or material by rail, he will in the first instance apply to the local station-master or Railway Transport Officer. If the latter is unable to carry out the requirements, the C.O. unit will apply to higher authority to make all necessary arrangements with Railway Companies concerned.

2. Due notice must be given to the local station-master or R.T.O. of any abnormal movement of personnel or material. The question of what is abnormal and of the notice to be given will depend on the amount of ordinary traffic at the station concerned.

3. Officers Commanding parties arriving by rail are responsible that the regulations of the Railway Companies are complied with. They are not to interfere with the railway service.

4. Railway Companies are usually willing to provide, without extra charge, special trains for parties of 150 and upwards, and even for less numbers on long distances, if ordinary trains are not suitable.

5. If the number of men to proceed is considerable, an advance party may be sent to the railway station on the day of entrainment to allot the carriages and make detailed arrangements.

The approach of the party to the station should be reported to the railway authorities in order that the route to be used within the station, and the halting places previous to entrainment, may be pointed out.

6. In the case of the movement of a unit at home, the women and children (with any light baggage accompanying them) will be entrained before the arrival of the men.

7. Baggage will, as a rule, be entrained prior to the arrival of the men, by the advance party.

8. The following rules should be borne in mind :—

(*a*) Interfere as little as possible with the railway management.
(*b*) Trucks and carriages must not be kept loaded up.
(*c*) Traffic should not be suspended except for very good reasons.
(*d*) No off-loading on the main line.
(*e*) No alterations once the time table is settled. But if unavoidable, an order in writing must be given to the railway staff.
(*f*) Troops must not occupy railway buildings or use the water supply without authority from a railway transport officer.

Entrainment of Men.

9. Compartments intended for 10 ordinary passengers are, as a rule, allotted to 8 men with their arms, accoutrements, and kits.

10. Previous to entrainment, men, with their kit-bags, etc., will be told off into sections corresponding with the capacity of the compartments provided, which should be numbered and lettered to facilitate entrainment.

11. The entrainment will take place by word of Command. It should be completed five minutes before the time of departure.

12. The first men to enter compartments will pass to the far side. Each man will stow away his kit-bag, etc., and Arms will either be retained or placed in the racks.

13. No man is to leave a carriage except when ordered by his officers or requested by the railway officials to do so.

14. If it is necessary to put airmen in trucks, allow 5½ square feet per man for short journeys or 7 square feet for journeys over 8 hours duration.

15. When the train is ready to proceed "Fall In" (General Parade) will be sounded.

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The Journey.

16. If the train is to halt at any place for the men to have refreshments, the Officer Superintending the entrainment should telegraph the departure of the train to the halting station, as well as to the place of final destination.

17. On arrival at the place appointed for the train to halt, the officers will get out and go to the carriages of which they are in charge. Sentries will be posted if necessary. The "Dismiss" will then be sounded, and men may get out of the train, leaving their arms in the carriages.

18. When it is time to proceed the "Fall In" (General Parade) will be sounded. Men will return to their carriages, and the officers will see that they are all present, and report to the C.O. Any sentries that have been posted will then be withdrawn. Lastly the officers will get in and the C.O. will then give instructions that the train may proceed.

19. In case of accident to the train, the officers will proceed at once to the carriages of which they are in charge, and the men will retain their seats until ordered to descend. Directions given by railway officials must be properly executed.

Detrainment.

20. In detrainments the O.C. of the party must ensure the speedy evacuation of the railway station.

21. The officers will proceed to the carriages of which they are in charge, and point out where the men are to form up. The men will then get out, taking their arms, kits, etc., which will be deposited in some convenient place, until ordered to fall in and march off.

22. The routes to be used on cross channel journeys between Great Britain, Ireland, the Channel Islands, or the Isle of Man, are those which are run by Railway Companies themselves, or by other lines of steamship run in conjunction with them.

23. Officers, officers' families, warrant officers, N.C.O's and men and their families, cadets and nurses, when travelling at the public expense use a travelling warrant, Form 413, which on presentation to a booking office, is exchanged for a railway ticket.

24. Army Form G.980 is used for the consignment of all R.A.F. Stores and Equipment and also for baggage of officers, other ranks, etc., entitled to be conveyed free at the public expense (less the amount carried free by the Railway Companies).

25. Army Form G.980 is only used in the United Kingdom. Abroad information as to the correct forms to be used should be obtained from the Railway Transport Officer.

Gauges.

26.

	ft.	ins.
Great Britain, France, Germany, Holland, Belgium, Denmark, Austria-Hungary, Italy, Switzerland, Sweden, Turkey, Egypt*, Canada, U.S.A.	4	8½
Russia	5	0
Ireland	5	3
Ceylon	5	6
Japan	3	6
Australia, N.S. Wales - 3 ft. 6 ins. and	4	8½
,, Victoria and South Australia	5	3
,, Queensland and W. Australia	3	6
New Zealand	3	6
Spain and Portugal	5	6
Asiatic Turkey - 4 ft. 8½ ins. and	3	5½
India - 2 ft 6 ins., 3 ft 3¾ ins. and	5	6
S. Africa	3	6
Width of roadway required for a single line (4 ft. 8½ ins. gauge)	12	0
Width of roadway required for a double line	23	0

*Also 3 feet 6 inch.

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American or Canadian Rolling Stock.

27.	Passenger car carries - - - - -	50 men.
	Horse car carries - - - - - -	16 horses unsaddled, or 12 ,, saddled.
	Stock car carries - - - - - -	18 ,, unsaddled.
	30-ton freight box car carries - -	30 men.
	Flat cars - - - - - - -	2 guns with limbers.

Russian Rolling Stock.

28.	Wagon, ordinary, carries - - -	40 men or 8 horses.

South African Stock.

29. (On South African railways the length of trains for men is usually limited to about 8 to 10 vehicles, and 30 short trucks in a goods train.)

Passenger Stock.	Normal Accommodation.
First class - -	6 compartments. Sitting, 36. Lying, 24.
Second class -	6½ compartments. Sitting, 52. Lying, 39.
Composite saloon	First class. Sitting, 18. Lying, 12. Second class. Sitting, 27. Lying, 21.
*Third class - -	7½ compartments. Sitting, 60. Lying, 15.
Other Stock.	
Long bogies -	60 to 80,000 lbs. These are not suitable to accommodate men.
Short bogies -	22,000 lbs.
†Short sheep -	22,500 lbs. or 8 horses, or 10 mules, or 20 men.
Bogie cattle truck	40,000 lbs. or 16 horses, or 20 mules or 40 men.
Short cattle truck	22,000 lbs. or 8 horses, or 10 mules or 20 men.
Horse boxes -	Seldom available. Accommodate 2, 3 or 4 horses, with proportion of attendants.

*For short coaches, calculate half this accommodation. This type is being eliminated. It is intended eventually to adopt the long coach as a standard type.

†Not procurable on Natal Lines.

42. TRANSPORT BY SEA.

General:

1. The Mercantile Marine Department of the Board of Trade is responsible for providing shipping for the sea transport of Air Force personnel and material. The requirements of the R.A.F. are notified to that Department by the Director of Equipment, Air Ministry. Overseas the local representatives of the Department are responsible for the provision of sea transport, on the application of the Air Officer Commanding.

The Director of Sea Transport is the head of the Mercantile Marine Department of the Board of Trade.

2. Conveyance is provided in—

(*a*) Transports (ships wholly engaged for the Government service).

(*b*) Freight ships (man)—ships in which conveyance is engaged for Air Force, but which are not wholly at the disposal of the Government.

(*c*) Freight ships (stores)—ships in which space is engaged for stores, but which are not wholly at the disposal of the Government.

Fitting and Inspection of Transports.

3. Transports are fitted for the conveyance of troops on ocean voyages in accordance with regulations laid down by the Director of Transports Special fitting is not required for short voyages.

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4. All transports are inspected before sailing by a Board consisting of the Master of the Transport, a representative of the Board of Trade, the Naval Transport Officer of the Port, the Military Medical Officer of the Port, the Medical Officer of the Transport (if available), and the Army and Air Force Embarkation Officers if army troops and/or Air Forces are proceeding on the voyage.

5. Special attention is paid on the inspection to the following :—

(*a*) Accommodation, especially as to cleanliness, compliance with regulations, and provision of proper space.

(*b*) Provision of baggage space, racks for sea kit bags, arm racks, and cooking galleys.

(*c*) Water, as to amount, quality and arrangements for issue.

(*d*) Feeding arrangements.

(*e*) Sanitary arrangements.

(*f*) Medical arrangements.

(*g*) Boats, as to condition, number and facilities for lowering.

Tonnage :

6. Gross tonnage is the total cubic space below deck and the total cubic contents of closed spaces above deck.

Net tonnage is the gross tonnage less all spaces not available for freight, accommodation for the crew, and space occupied by engine rooms, coal bunkers, etc.

Freight tonnage is a measure of cubic capacity, a freight-ton being 40 cubic feet of cargo space.

7. Tonnage tables are included at end of Section giving the dead weight and shipping tons of R.A.F. material.

The following points are to be borne in mind :—

(*a*) For stowing vehicles, clear floor space is necessary. All height above the vehicle is lost stowage.

(*b*) In preparing vehicles for shipment, magnetos and other loose parts should be taken off and shipped separately in a case by themselves.

(*c*) All petrol and oil must be emptied out of the vehicles before shipment.

(*d*) Only light articles can be stowed on the top of aeroplane cases.

(*e*) R.A.F. material is very bulky for shipment in proportion to its weight. As a general guide, it may be noted that about 7 cubic tons equal one ton dead weight.

Embarkation and Disembarkation :

8. (*a*) An Airman proceeding overseas is supplied with two kit bags—one a bag, sea, kit, for articles for use on the voyage, and the other a kit bag of ordinary dimensions, which will be stowed in the baggage room. If bags, sea, kit, are not available, ordinary kit bags may be utilised, but must not be filled to more than two-thirds of their capacity, as otherwise they cannot be stowed upon the racks provided in the transports.

(*b*) All baggage and kits of all ranks must be clearly marked with the name of the owner and his destination.

(*c*) On arrival at the port of embarkation or disembarkation, all ranks will be fallen in alongside the transport and the strictest discipline will be maintained.

(*d*) Airmen detailed to messes by the Embarkation Officer cannot change the number of their mess.

(*e*) N.C.O's. in charge of messes will be responsible for using every endeavour while on the voyage to make their mess the cleanest and most orderly of the troop deck.

(*f*) Hooks in the deck beams overhead on the troop decks are for the slinging of hammocks only and must not be used for any other purpose.

(*g*) Draft conducting officers are at all times responsible to the O.C. Royal Air Force on board, and the O.C. Troops for the condition of the troops' berth in troop decks.

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They must be personally on the troop decks when airmen are actually embarking, and see that silence and order is preserved while the men are filing into their messes and during the final inspection.

(*h*) Airmen should wear overalls when engaged on fatigues on board ship, as otherwise considerable damage is done to the service dress.

(*i*) Canvas shoes are required for use on board ship.

Officers' Baggage :

9. On arrival of the transport in the United Kingdom, all officers travelling on board should have ready a list giving a short description of each item of their personal baggage and of the contents. The list is required by the Embarkation Officer for passing baggage through the Customs and saves considerable delay.

NOTES ON MOVEMENTS OF STORES.

Tonnage.

Tables :

10. Tables appended enable tonnage required to be worked out according to requirements.

Facilities :

11. On Active Service. Information should be obtained beforehand as to :—

(i) Berthing facilities.
(ii) Depth of water low and high tides.
(iii) Quay space for off-loading.
(iv) Position of dumps to which stores may be removed after landing to avoid congestion of quays.
(v) Lifting tackle available.
(vi) Rail facilities at quay side, and number of trucks which can be accommodated on siding. Gauge, availability of trucks and general sizes.
(vii) Road facilities; nature, condition and width.

Preparation and Marking :

12. All preparation should be made beforehand and duties assigned.

All cases should be marked as to contents and it should be noted that the *items required first* should be *loaded last.*

Strong cases should be held sufficient to take all stores necessary.

Special steps should be taken to lock up any supplies or stores liable to be pilfered by native labour if employed.

Appliances for Loading and Off-Loading :

13. Slings and appliances for loading or off-loading are needed. The following items will be required wholly or in part :—

(i) 14 ft. tripod legs with eye for 15 cwt. tackle.
(ii) Stout fold-up benches for flights workshops and M.T.
(iii) Stout axles and wheels for moving Aero. cases.
(iv) Tube steel rollers 10 ft. × 6 ins. diameter for moving Aero. cases.
(v) Tube steel rollers 5 ft. × 4 ins. diameter for moving heavy cases.
(vi) "Tray" slings 10 ft. × 4 ft. for bombs, petrol, and small stores that need careful slinging.
(vii) "Net" slings for stores awkward to handle, such as camp equipment, etc.
(viii) A number of rigging t estles (including two pairs of heavy uprights with cross-bars for under-carriage repairs).
(ix) Engine stands.

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(x) A quantity of rough timber for general purposes, such as :—
(*a*) Battening transport, machines, etc., on rail and ship.
(*b*) Repair of hangar parts trestles, etc.
(*c*) Repair of camp equipment.

(xi) Trollies for handling stores over rough ground.

Aeroplanes in Cases :

14. If aeroplanes are to be dismantled and packed in cases, the same personnel should if practicable carry out this work. Parts required for re-erection should be kept with the aeroplane, together with reserve of such items as split pins and rubber connections, so that work of erection can proceed without delay. If necessary, parts such as R.A.F. wire should be labelled or marked with aeroplane numbers. Wings should be packed in aero cases and labelled with aeroplane number.

Aeroplanes Uncased :

15. If aeroplanes are to be transported uncased, wings, elevators, and undercarriage wheels should be removed, and the fuselage firmly chocked and lashed. Special slings designed to lift the fuselage at the proper points may be necessary.

When aeroplanes are transported with engine in place, extra supports should be placed from floor to airscrew shaft. It is not desirable to transport aeroplanes uncased unless skilled labour is available to handle.

If trucks of sufficient length are not available a fuselage can be mounted on timbers on one flat truck with "runner" trucks at the ends to allow for swinging.

M.T. Vehicles :

16. Use must be made of lorries for storage and these should be last on and first off.

An end ramp saves much time in unloading M.T. vehicles from rail.

For a workshop lorry the floor of a truck may need strengthening by timbers.

Petrol :

17. Petrol in small cans should be carefully loaded. Trays and not slings should be used. On rail closed trucks with double roof should be used if practicable. This minimises evaporation.

Open trucks must be convoyed.

Camp Equipment and Water Carts :

18. These should be immediately accessible.

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TRANSPORTATION TABLE A.

Details of Transportation of Equipment of 1 Wing Headquarters, 3 Squadrons (12 aeroplanes each), and an Aircraft Park. (A.P. to consist of Stores Section, A.R.S., E.R.S., and M.T.R.S.).

Section.	Nature of Equipment.	Wing Headquarters.					1 Squadron : B.F. or D.H.9.					1 Aircraft Park with 3 months' supply for 3 Squadrons.					Remarks.
		No. of pkgs.	Dd. Tns.	Wt. cwts	Shpg. Tns.	Tnge. Feet.	No. of pkgs.	Dd. Tns	Wt. cwts	Shpg. Tns.	Tnge. Feet.	No. of pkgs.	Dd. Tns.	Wt. cwts	Shpg. Tons.	Tnge. Feet.	
1 A	Hand tools -	—	—	—	—	—	40	1	10	4	0	55	2	10	6	0	
2A & B	Machine tools, etc. - -	—	—	—	—	—	2	—	3	—	28	12	5	0	7	0	
4	Aerodrome equipment	—	—	—	—	—	40	1	0	3	0	45	1	4	3	15	
5 & 6	Electrical equipment and Aero instruments	—	—	—	—	—	3	—	3	—	10	4	—	4	—	12	
7, 8 &11	Armament -	—	—	—	—	—	41	2	9	4	25	12	—	15	1	5	
10	W.T. equipment -	—	—	—	—	—	4	—	7	—	39	4	—	7	—	39	
12	S.A.A. and Pyrotechnics	—	—	—	—	—	102	2	10	2	31	600	15	0	18	0	
14	Photographic equipment	—	—	—	—	—	28	—	12		18	12	8	8	—	10	
11B to H	M.T. Stores -	—	—	—	—	—	8	—	18	2	0	32	3	12	6	0	
1A, 20,	Camp equipment.	14	1	14	11	2	20	2	2	12	26	35	3	13	17	7	
22	Clothing -	20	—	18	3	10	87	3	18	13	14	313	11	14	36	9	
24	Planes - -	—	—	—	—	—	1	1	2	19	5	12	13	19	119	0	
25	Propellors -	—	—	—	—	—	1	—	3	—	28	15	1	19	10	11	
26 & 27	Aero spares -	—	—	—	—	—	6	1	7	3	10	45	11	28	47	28	

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TRANSPORTATION TABLE A.—*continued.*

Section.	Nature of Equipment.	Wing Headquarters.					1 Squadron : B.F. or D.H. 9.					1 Aircraft Park with 3 months' supply for 3 Squadrons.					Remarks.
		No. of pkgs.	Dd. Tns.	wt. cwts	Shpg. Tns.	Tnge. Feet.	No. of pkgs.	Dead Tns.	wt. cwts	Shpg. Tns.	Tnge. Feet.	No. of pkgs.	Dd. Tns.	wt. cwts	Shpg. Tons.	Tnge. Feet.	
28 to 32	A.G.S. Metals, timber and soft goods -	—	—	—	—	—	5	—	18	3	0	27	14	5	11	2	
33	Paints and dope	—	—	—	—	—	3	—	3	—	4	35	1	15	1	8	
35	Aero engines (in cases) -	—	—	—	—	—	4	2	0	7	8	36	18	0	70	0	Including 100% reserve with A.P.
36	Aero engine spares -	—	—	—	—	—	10	2	18	6	0	54	21	6	32	0	
	Total above (Wing and Sqd. supplies carried in M.T. vehicles) -	34	2	12	14	12	404	24	3	74	6	1,348	116	19	467	26	
17A	Complete vehicles (empty)	7	7	10	88	31	45	96	15	1,016	22	64	121	17	1,429	12	Including 25 per cent. reserve with A.P.

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Total shipping weight and measurement	7	10	2	88	31	45	110	18	1,016	32	1,412	238	16	1,896	38	
Add Oil and Petrol -	117	4	15	8	2	1,500	60	0	100	—	14,731	590	0	999	4	
Add aircraft in cases -	—	—	—	—	—	12	30	0	504	—	36	90	0	1,512	0	Including 100% reserve with A.P.
Add Bessonneau hangars (3 per Sqdn. and 8 for A.P.)	—	—	—	—	—	249	29	0	174	—	664	72	0	464	0	Allowing for half reserve machines to remain in cases.
Grand Total without tents -	124	14	17	96	33	1,806	229	18	1,794	32	16,843	990	16	4,872	42	Bombs extra as required.
Tentage if required -	19	1	0	5	11	38	1	12	8	12	62	2	6	12	33	
Grand Total with tents -	143	15	17	102	4	1,844	230	30	1,803	4	16,905	992	22	4,885	35	do. do.

	1 Wing H.Q., 3 Squadrons and 1 A.P.				
Total Force without tents and without bombs -	22,385	1,695	7	10,353	11
Total Force with tents but without bombs - -	22,580	1,703	9	10,396	11

Based on Wing H.Q. Estab. 1/4/21, Sqd. Estab. 1/4/21 (A.M. File S.14072 30/11/20).

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TRANSPORTATION TABLE B.

Weights and Shipping Measurements of R.A.F. Equipment to be carried by a Squadron (12 aeroplanes) and a Distributing Unit on an Expedition of 3 Months' duration without Repair Shops.

Note.—Squadron to carry articles in use plus one month's replacements. Distributing Unit to carry one month's replacements, no mechanical transport to be taken. No clothing to be carried by Squadron.

Section.	Equipment.	By a twin-engine squadron.		By a D.U. for Ditto.		By a single-engine squadron.		By a D.U. for Ditto.		Remarks.
		Weight tons.	Measurement. tons.	Weight tons.	Measurement. tons.	Weight tons.	Measurement. tons.	Weight tons.	Measurement. tons.	
1A	Hard tools	1·5	4·0	·37	1·0	1·5	4·0	·37	1·0	
2B	Lifting tackle, etc.	1·0	6·0	·25	1·5	·15	·5	·03	·12	
4	Aerodrome equipment	2·0	6·0	·50	1·5	1·0	3·0	25	·75	
5 and 6	Aircraft electrical and aero instruments	·2	·5	·6	1·5	·15	·25	·45	·75	
7, 8 and 11	Armament	3·0	5·0	1·2	2·0	2·3	4·5	·75	1·12	
10	W.T. equipment	·3	1·0	·07	·25	·3	1·0	·07	·25	M.T. spares omitted.
12	Bombs, ammunition and pyrotechnics	*See* Table C.								Only a small quantity of clothing allowed to cover losses.
14	Photographic equipment	·5	·5	1·0	1·0	·5	·5	1·0	1·0	
20 and 21	Camp equipment	2·1	12·5	1·25	5·5	2·1	12·5	1·25	5·5	
22	Clothing	—	—	·10	1·0	—	—	·10	1·0	
24	Planes	·36	6·41	1·08	19·23	1·1	19·25	3·5	60·0	Heavy bomb planes in components.
25	Propellers	·33	1·25	·99	3·75	·16	·62	·8	3·1	
26 and 27	Other aero parts	2·6	6·5	7·8	19·5	1·3	3·25	3·9	9·75	Timber and metals omitted.
28–32	A.G.S. and soft goods	·25	1·0	·75	3·0	·25	1·0	·75	3·0	
33	Dopes	·2	·12	·6	·36	·1	·1	·3	·3	
35	Spare aero engines	25 per cent. stationary and 30 per cent. rotary on numbers in use—*See* Table D.								
36	Aero engines spares	1·0	3·05	3·0	9·15	1·0	3·05	3·0	9·15	
	Oil and Petrol	*See* Table E.								
	Aircraft	*See* Table F.								
	Hangars	*See* Table Section 18.								
	Mechanical transport	*See* Table G.								

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TRANSPORTATION TABLE C.—BOMBS, AMMUNITION AND PYROTECHNICS.

Description.	No. per package.	Size of package.	Shipping measurement in cub. ft.	Weight approx. in lbs.
		Standard Bombs.		
Bombs H.E. 230 lbs.	1	55½″×17½″×17½″	9·75″	250
,, 112 ,,	1	32 ″×16½″×16½″	5·	135
,, 20 ,,	1	26 ″× 6½″× 5½″	·5	27
		Small Arm Ammunition.		
C.S.A. Ball ·303 Bandoliers	1,000	1′ 4 ″×8 ″× 10½″	·77	74
,, Special	1,248	1′ 4 ″×8 ″× 10½″	·77	84
,, ,,	768	1′ 4½″×6 ″×1′ 1 ″	·75	56
C.S.A. Ball ·455	252	9 ″×6½″× 4½″	·15	15
(auto pistol)	210			
C.S.A. ·455 (revolver)	2,160	1′ 4 ″×8 ″× 10½″	·71	112
		Pyrotechnics.		
Cartridges, signal, 1½″	72	1′ 4 ″× 8 ″× 10½″	·77	32
	96	1′ 4½″× 10 ″×1′ 1 ″	1·23	42
Flares, landing, W.T.	25	1′ 4 ″× 10 ″×1′ 2 ″	1·24	56
Bombs, flare reconnaissance	4	2′ 2 ″× 10 ″× 10½″	1·61	48
,, ,, Michelin, long	2	4′ 6 ″×1′ 4½″× 10 ″	5·09	112
,, ,, short	2	3′ 10 ″×1′ 3 ″× 10 ″	4·	90
Rockets lb. magnesium	24	2′ 3 ″×1′ 5 ″× 6 ″	1·6	44
,, 1 ,, ,,	20	1′ 7 ″×1′ 6 ″× 8 ″	1·4	35
,, 1 ,, ,,	15	1′ 6 ″× 10 ″× 6½″	·71	18
,, 1 ,, ,,	10			
,, sticks, bundles of	50	5′ × 9 ″× 4 ″	1·25	18
Flares, ground 1½″×1½″	182	2′ ×1′ 3 ″× 6 ″	1·25	49
,, ,, ,,	250	1′ 4 ″×1′ ×1′	1·33	53
Lights, short	In specific packages—bulk insignificant.			
,, portfire				

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TRANSPORTATION TABLE D.—AERO ENGINES.

Type.	No. of Cases.	Dimensions of Cases.	Dead Weight.	Shipping.	Total No. of Cases M/C and Engine.	Total Dead Weight M/C and Engine.	Total Shipping Tons M/C and Engine.
			Tons cwt.	Tons		Tons cwt.	Tons
Mono - -	1	3′ 9″ × 3′ 9″ × 3′ 8″	0 8	1·30	2	2 13	40·51
Falcon 3 - -	1	6′ 7″ × 3′ 9″ × 4′ 7″	0 15	2·82	2	3 4	40·51
Liberty - -	1	6′ 7″ × 3′ 2″ × 4′ 4″	0 14½	2·25	2	3 12½	46·53
B.R. 2 - -	1	4′ 3″ × 4′ 5″ × 4′ 3″	0 8	2·0	2	2 6	32·32
Eagle 8 - -	2	7′ 0″ × 3′ 10″ × 4′ 6″	1 12	6·0	4	8 12	126·50
Lion - -	2	7 ′0″ × 4′ 3″ × 4′ 7″	1 12	6·80	9	9 17¾	125·80
Lion- - -	2		1 12	6·80	6	13 2	225·54
Eagle 8 - -	1		0 16	3·0	3	4 4	64·08
Eagle 8 - -	2		1 12	6·0	6	10 10	226·45
Lion - -	1		0 16	3·40	2	4 16	73·65
Lion - -	1		0 16	3·40	2	4 16	79·0
B.R. 2 - -	1		0 8	2·0	2	2 6	31·80
Lion - -	1		0 16	3·40	2	4 17	81·73

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Lion - -	1			0	16	3·40	2	4	1	73·20
Eagle 8 - -	2			1	12	6·0	6	—		276·0
Jupiter - -	1	5′ 8½″ × 4′ 3″ × 5′ 8″			15¾	3·50	3	2	7	75·42
Condor - -	1	8′ 7″ × 5′ 1″ × 3′ 7″		1	5	3·90	3	7	12	79·47
Lion- - -	2			1	12	6·80	4	6	18	114·28
Jaguar - -	1	4′ 9½″ × 5′ 0″ × 4′ 8″			14	2·80	2	2	14	32·45
Jupiter - -	1				15¾	3·50	2	2	18¼	27·65
Jaguar - -	1				14	2·80	—	—		44·85

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TRANSPORTATION TABLE E.—PETROL AND OIL.

Description.	Quantity per package.	Description of package.	Size of package.	Shipping measurement.	Weight.
Petrol - -	8 gallons in 2-gallon tins	Case W.P.- -	22½″×14½″×14 ″	2.65 cub. ft.	94 lbs.
,, (abroad)	8 gallons in 4-gallon tins	Case W.P.- -	21 ″×11 ″×15½″	2.65 ,,	94 ,,
Oil - - -	5 gallons - - - - -	Steel drums -	17 ″×11¼″×11¼″	1.25 ,,	54.5 ,,

Petrol and Oil Consumption per hour.

Standard Aero Engines.

Type of engine.	Petrol.		Oil.	
	Pints.	Galls.	Pints.	Galls.
Mono. - - - - -	89·8	11·22	15·6	1·95
B.R II - - - - -	138·0	17·25	18·0	2·25
Falcon III - - - -	147·8	18·47	6·6	·82
Eagle VIII - - - -	198·0	24·75	7·78	·97
Liberty - - - - -	193.0	24·12	14·6	1·82
Lion II - - - - -	234·9	29.36	13·5	1·69

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TRANSPORTATION TABLE F.—AIRCRAFT.

Type.	No. of Cases.	Dimensions of Cases.	Dead Weight. T. C.	Shipping. Tons.
Avro - -	1	27′ 6″ × 7′ 9″ × 7′ 5″ -	2 5	39·21
Bristol F. -	1	do. -	2 9	39·21
D.H.9A - -	1	30′ 5″ × 7′ 9″ × 7′ 7″ -	2 18	44·28
Snipe - -	1	21′ 4″ × 7′ 8″ × 7′ 5″ -	1 18	30·32
V. Vimy - -	2	27′ 5″ × 7′ 2″ × 11′ 0″ (fuselage) - - -	7 0	120·5
		26′ 4″ × 8′ 5″ × 12′ 0″ (planes) - - - -		
V. Vernon -	7	24′ 10″ × 11′ 3″ × 3′ 5″ (2) (planes) - - - -	8 5¾	119·0
		23′ 6″ × 6′ 0″ × 9′ 1″ (fore part cabin) - - -		
		16′ 0″ × 7′ 9″ × 4′ 10″ (rear part fuselage) - - -		
		17′ 0″ × 6′ 11″ × 3′ 0″ (tail unit) - - - -		
		11′ 6″ × 8′ 0″ × 5′ 10″ (engine mounts) - -		
		9′ 0″ × 9′ 0″ × 1′ 7″ (propellers) - - - -		
V. Victoria -	4	31′ 4″ × 7′ 4″ × 10′ 6″ (front of fuselage) - -	3 5	60·55
		24′ 9″ × 6′ 7″ × 9′ 7″ (rear part of fuselage) - -	2 10	39·04
		33′ 4″ × 7′ 8″ × 14′ 11″ (main planes) - - -	3 15	95·30
		14′ 5½″ × 6′ 0″ × 11′ 0″ (spares) - - - -	2 0	23·85
Fairey 3D -	2	30′ 4″ × 7′ 11″ × 7′ 10″ -	3 8	61·68
		18′ 5″ × 6′ 10″ × 4′ 8″ (floats and trolley) - -		
F.2A - -	4	44′ 6″ × 15′ 3″ × 9′ 0″ (crate) - - - -	8 18	220·45
		30′ 4″ × 7′ 11″ × 8′ 9″ (planes) - - - -		
		9′ 0″ × 2′ 6″ × 2′ 6″ (trolley wheels) - - -		
		8′ 7″ × 8′ 7″ × 2′ 1″ (propellers) - - - -		

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TRANSPORTATION TABLE F.—*continued.*

Type.	No. of Cases.	Dimensions of Cases.	Dead Weight. T. C.	Shipping. Tons.
Dart	1	34′ 1″ × 8′ 10½″ × 9′ 3½″	4 0	70·25
Seagull	1	34′ 9″ × 9′ 8″ × 9′ 0″	4 0	75·60
Nightjar	1	21′ 5″ × 7′ 7″ × 7′ 5″	1 18	29·80
Blackburn Fleet Spotter	1	35′ 3″ × 9′ 0″ × 9′ 10½″	4 1	78·33
Aero Bison	1	34′ 6″ × 9′ 0″ × 9′ 0″	3 5	69·80
F.5	4	50′ 0″ × 16′ 0″ × 10′ 0″ (crate) 35′ 0″ × 8′ 0″ × 9′ 0″ (planes) 9′ 0″ × 3′ 0″ × 3′ 0″ (trolley wheels) 9′ 0″ × 9′ 0″ × 2′ 6″ (propellers)	—	270·0
Duiker	2	23′ 0″ × 3′ 0″ × 13′ 0″ (planes) 33′ 0″ × 6′ 0″ × 10′ 0″ (fuselage, etc.)	1 11½	71·92
Aldershot	2	42′ 0″ × 4′ 9″ × 7′ 6″ (*f*) 27′ 6″ × 6′ 0″ × 9′ 3″ (*p*)	6 7	75·57
Fawn	2	31′ 6″ × 8′ 0″ × 9′ 6″ (*f*) 27′ 6″ × 8′ 3″ × 8′ 6″ (*p*)	5 6	108·10
Flycatcher	1	21′ 4″ × 7′ 6″ × 7′ 5″	2 0	29·65
Plover	1	23′ 0″ × 6′ 0″ × 7′ 0″	2 3	24·15
Siskin	1	24′ 10½″ × 7′ 9″ × 8′ 10″	—	42·5

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TRANSPORTATION TABLE G.—MECHANICAL TRANSPORT.

Vehicle.	Tonnage.				Length	Width	Height.	
	Weight.		Standing.	Cut down.			Standing.	Cut down.
	T.	C.	T. ft.	T. ft.				
Crossley touring car	1	18¼	17 0	— —	17′ 0″	6′ 0″	6′ 8″	— —
Crossley landaulette	1	19¼	18 20	— —	17′ 0″	6′ 0″	7′ 3″	— —
Crossley light tender	1	18¼	22 6	— —	16′ 3″	6′ 5″	8′ 6″	— —
Crossley ambulance	2	4¼	18 11	— —	14′ 6″	6′ 2″	8′ 2″	— —
Leyland heavy tender	4	6¼	41 35	28 22	21′ 9″	7′ 0″	11′ 0″	7′ 6″
Leyland instrument repair lorry	4	6¼	41 35	— —	21′ 9″	7′ 0″	11′ 0″	— —
Leyland workshop lorry	6	15¼	43 12	— —	22′ 0″	7′ 0″	11′ 3″	— —
Leyland photo lorry	5	4	46 34	— —	23′ 0″	7′ 1″	11′ 6″	— —
Lacre trailer	3	17¼	8 0	— —	15′ 3″	6′ 0″	3′ 6″	— —
Mark 1A trailer	—	16¼	14 14	— —	25′ 6″	6′ 9″	3′ 4″	— —
Wing trailer	1	4¼	31 7	— —	22′ 8″	6′ 10″	9′ 3″	— —
H.P. trailer	—	—	116 29	— —	39′ 0″	8′ 6″	14′ 1″	— —
Instrument repair trailer	2	0	32 35	— —	15′ 5″	7′ 6″	11′ 4″	— —
Water cart	—	15¼	11 11	— —	11′ 6″	6′ 10″	5′ 9″	— —
Clayton tractor	3	2¼	8 22	— —	10′ 4″	5′ 6″	6′ 0″	— —
Ford Hucks starter	—	14¼	16 35	— —	14′ 9″	5′ 7″	8′ 4″	— —
P.&M. Motorcycle	—	2¼	1 28	— —	6′ 10″	2′ 11″	3′ 5″	— —
P.& M. Sidecar	—	1¼	2 7	— —	5′ 7″	5′ 0″	3′ 1½″	— —
Sentinel steam wagon	7	5	31 9	— —	20′ 3″	7′ 3″	8′ 6″	— —
Motor roller	5	8	16 26	— —	11′ 10″	6′ 3″	9′ 0″	— —
Motor mower	—	18¾	4 12	— —	7′ 10″	4′ 9″	4′ 8″	— —

WEIGHTS OF VARIOUS ARTICLES.

Note.—For Ammunition and bombs - - *See* Table A.
Engines - - - - - „ „ B.
Petrol and oil - - - - „ „ C.
Aeroplanes - - - - „ „ D.
Mechanical Transport - - „ „ F.
Field Kits - - - - „ Section 9
Hangars and tents - - - „ „ 18

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Cameras :

	Bare weight. (lbs.)	How packed.	Gross weight. (lbs.)
"B" type with lens and 6 slides	27	Storage case	63
"L" type with lens, sheaths and drive	31	,, ,,	52
Do. bare	15		
"W.A." type with lens and 6 slides	22	,, ,,	58
"P" type with lens and slide	10¼	,, ,,	24
Mark III. Hythe	18¾	,, ,,	37½

Electrical Heating Apparatus :

Generators, Mk. II., Lucas	11¼	1 case, size 27″×19″×16″	
Cable, switchboxes, etc.	11	,, ,,	
Accumulators, 12v., Mk. III.	19¾	,, ,,	
Clothing Elect. Heat (Waistcoat 38″×6′, Soles (8), Gloves (9))	3		
Electrical heating equipment for two persons	49		

Guns :

Lewis ·303 No. II, Mk. III.	17	Gun Chest	51
Vickers ·303, Mk. II.	23	,,	56
C. gears, type "C" single, with 9 ft. pipe line	15	—	—
Do. double	18	—	—
Total	73		

Oxygen Apparatus :

Regulators Dreyer, Mk. I.	5½	In box	6¾
,, Mk. II.	2¾	,,	3¾
Additions :—			
Containers Liquid Oxygen	29	In basket and	49½
Vapourisers ,, ,, 5 litres	11¾	slag wool	18½
,, ,, ,, 4 ,,	16½	,,	23
,, ,, ,, 3 ,,	10¼	,,	16¾
,, ,, ,, 1 ,,	11½	,,	17¾
Holders for 5 litre vapourisers	4½	Fitted to and	
,, ,, 3 ,, ,,	3	packed with vapourisers.	
Tubing, meters and fittings	4¾	In box	1
Baskets	6½		

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Wireless :

	Bare Weight.	How packed.	Gross Weight.
	(lbs.)		(lbs.)
Tuner, Mark III, C.W. - - -	17		
Aerial Transmission Set, Complete.			
Transmitter, T.21 - - - -	9		
Attachment Telephone - - -	5¼		
Key transmitting - - - -	1		
Brackets, Alum; Suspension, fitted (2 pairs) - - - - -	3		
Generator, 1,500 volts - - -	12		
Training arm - - - - -	5½		
Total - -	35¾		
Wireless Receiving Station, complete.			
Receiver Model T.F. with socket and 4-way lead - - - -	8½		
Receivers, telephone patt. 520 -	1		
Accumulators, 6-volt, 30 amp hr. -	15¾		
Batteries, inert 15-volt unit - -	6¼		
Boxes, battery, 90-volt - - -	2		
Total - -	31½		

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Chapter IX.

METEOROLOGY.

43. GENERAL METEOROLOGICAL NOTES.

1. The meteorological information of value to aeronauts falls under three heads (1) surface conditions, including frequency of fogs, gales, rain and snow, thunder, etc., and direction of prevailing winds; amount of low cloud is included with these; (2) upper air conditions, including temperatures at high levels, upper winds and information as to convection, "bumps," etc.; and (3) weather forecasting.

Surface Conditions :

2. The frequency of *fog* and *mist* is of great importance, but unfortunately until recently the meaning of these terms has not been defined with sufficient precision, and comparative estimates between different places are hard to obtain. Fog is now defined as atmospheric obscurity which limits visibility to less than 1,100 yards. In sub-tropical and tropical countries mist is often prevalent in the early morning; fog is very rare at low levels but occurs on the slopes of mountains where it is really a cloud formation. The definition of a *gale* is a wind with a velocity of 39 miles per hour or upwards. Gales occur at times in most parts of the world but are infrequent except on temperate seaboards (*see* section on England). In parts of the tropics very destructive gales are occasionally met with (typhoons, hurricanes, cyclones) in which the wind speed may exceed 100 miles an hour; these present absolutely impossible conditions for flyng and would even destroy any aeroplane or airship moored in their path (*see* India, Far East). *Rain* is not generally a hindrance in temperate latitudes, but in the tropics it may be torrential, and is frequently associated with severe *thunderstorms*, in which the air is very disturbed. Rainfall is also an index of the amount of low cloud, rain or drizzle, and poor visibility may give rise to conditions very unfavourable to flying and impossible where there is much high ground.

3. In estimating *Cloud Amount*, it has not been the practice to measure separately the amounts of low, middle and high cloud, and the figures given refer to all three types. "Low cloud" includes the following :—

Stratus, a uniform cloud layer without definite structure, which may have any height from ground level to 3,000 feet. Unless divided into ragged masses by the wind, stratus clouds generally indicate quiet steady conditions.

Cumulus. The characteristic features of a cumulus cloud are a flat base and a round bulging top. Each cloud covers a comparatively small portion of the sky; the bases of the clouds are approximately at one level. Cumulus clouds form when the lower air has been well stirred by convection currents. Rising air expands and cools but the cooling is not so rapid if it is accompanied by condensation, and accordingly, when a cloud has formed, it tends to rise and suck up air from below, the motive power being derived from the difference of temperature between the warm air inside the cloud and the colder air outside it. Cumulus clouds have small beginnings but they may grow until they reach from the base level of, say, 4,500 ft. up as far as 20,000 ft. when they develop into Cumulo-Nimbus.

Cumulo-Nimbus. When Cumulus clouds develop into great masses rising in the form of mountains, towers, or anvils, with a veil of fibrous cloud at the top and perhaps a dense shapeless cloud at the base, a thunderstorm is to be anticipated. The front of a thunderstorm of wide extent is frequently in the form of a large low arch above a region of uniformly lighter sky.

Strato-Cumulus is a frequent cloud in temperate latitudes. It forms large lumpy masses or rolls of dark grey cloud, frequently covering the whole sky, especially in winter. Sometimes it shows great rolls arranged in parallel lines close together (Roll-cumulus). Strato-cumulus is generally below 7,000 feet; it rarely brings rain.

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Nimbus is a dense layer of dark shapeless cloud with ragged edges from which steady rain or snow usually falls. The lower edge is almost invariably below 7,000 feet; it may be of considerable thickness and has other clouds above it.

The Middle Clouds (*Alto-stratus* and *Alto-cumulus*) are usually at a height of 10,000 to 23,000 feet; they are thin and of little importance from an aeronautical point of view. This applies still more to the upper clouds (*Cirrus*, *Cirro-stratus* and *Cirro-cumulus* or Mackerel sky), which have an average height of 30,000 feet and are very tenuous. The value of clouds in forecasting will be discussed later.

Upper Air Conditions:

4. In considering *upper air temperatures* it must be remembered that temperature falls with height at the average rate of 1° F. per 300 feet. Thus if the temperature on the ground reads 50° F., the freezing point may be looked for between 5,000 and 6,000 feet. The diurnal variation of temperature affects the lowest layers of the air only, and in the night or early morning there may be a reversal of gradient, the temperature rising until a height of perhaps 1,000 feet is reached. In any individual flight also, sudden fluctuations of temperature may be met with as one layer is left for another.

5. In the British Isles temperature continues to fall until a height of six or seven miles is attained (average temperature, −67° F.), after which it rises again. Near the equator however the fall extends to a much greater height and very low temperatures have been met with.

6. In *Upper winds* in temperate and sub-tropical regions, two tendencies are apparent. First, all winds in the northern hemisphere tend to veer through about 30 to 45 degrees and to increase in velocity upwards through the lowest 3,000 feet. Superposed on this, and extending to the highest levels of observation, is a tendency for the easterly component to die out and to be replaced by an increasing westerly component. Thus, for instance, a south-west wind at the surface is likely to veer to west at a small height and to continue to increase in velocity upwards. A north-east wind will veer to east, and then decrease in velocity until it dies out and is replaced by a westerly current. A south-east wind will veer to south-west and continue to increase, but a north-west wind, after veering slightly, will probably back to west again. Although the wind speed at the surface shows a maximum in the afternoon and a minimum in the early morning, the reverse is the case at heights of 1,000 feet and above.

7. With regard to *turbulence*, "bumps," etc., it must be remembered that these effects are of two kinds; those due to unequal heating of the earth's surface, and those due to the wind blowing across irregularities of the ground. The liability to turbulence depends largely on the extent to which there is stratification. If the air is much hotter below than above an exchange between the upper and lower layers takes place readily, and large eddies are produced in the wind current. On the other hand, when the air is colder below than above, eddies are damped out and the flow of air is more regular. It is clear that greater turbulence is to be expected in the middle of the day than at the times of sunrise and sunset, and greatest of all in tropical regions. The amount of turbulence in a particular wind also depends on the nature of the surface over which it is flowing.

Forecasting:

8. Where possible, such forecasts as are required should always be obtained from the regular Meteorological Services. Under each local heading a brief resumé is given of the use of the barometer, wind changes and sky signs in forecasting; but it must always be remembered that such methods require a great deal of local experience, and are rarely so effective as the use of a synoptic chart. During the fine weather seasons in Egypt, Mesopotamia and to a less extent India and the Far East, the meteorological conditions are very stable, and vary little from day to day.

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44. METEOROLOGICAL NOTES.—BRITISH ISLES.

urface Conditions :

1. The *climate* of the British Isles is essentially temperate, with mild winters and cool summers, much cloud at all seasons and no well-marked rainy period. From the barometric stand-point the British Isles come under the influence of the great Atlantic (Icelandic) minimum of pressure, especially in winter. This minimum is not, however, a stable phenomenon; if a series of daily weather charts be examined, it will be seen that the actual distribution of pressure changes from day to day, often very rapidly. There is frequently a system of closed isobars surrounding a "depression," which moves across the region, generally from some westerly or south-westerly direction, at an average speed of over 500 miles daily. The average pressure distribution is merely equivalent to superposing numerous daily pressure maps, the average being lowest where depressions are most frequent and of greatest depth. On any one day, however, the normal low pressure area off Iceland may actually be occupied by a high pressure system. The majority of the individual paths of depressions pass far to the north-west of the coastline formed by Northern France and Holland, but of these a large number pass over the British Isles. The paths have been grouped into "tracks," and these tracks are of great importance to West European weather. The main track lies along the north-west of Ireland and the north-west of Scotland. The central parts of a depression bring rain and wind according to its intensity; in the front the winds are southerly with warm and muggy weather, while in the rear the winds are northerly or north-westerly with bright and cold weather. Consequently the rapid passage of a series of depressions is associated with changeable weather, dull and bright days succeeding each other and creating a character for fickleness. It must, however, be understood that at any given place the weather is not definitely cyclonic on the majority of days.

2. *Average pressure distribution* undergoes a considerable change from summer to winter. In winter (Fig. 105) the well marked Icelandic minimum, divided into two parts, accompanies a steep pressure gradient from south to north. This means the predominance of strong westerly or south-westerly winds over the British Isles, with passage of numerous depressions, frequently accompanied by gales. The depressions of winter are large, sometimes several thousand miles in diameter. In summer (Fig. 106) the Icelandic minimum persists but with greatly weakened intensity, and the Azores maximum has moved northward so that pressure is relatively high over the whole North Atlantic. The prevailing winds over the British Isles and North Sea are still south-westerly. Depressions from the Atlantic are comparatively rare and are replaced by shallow irregular patches of low pressure which favour the production of local showers and thunderstorms. Spring and autumn are intermediate in type; depressions have their maximum frequency from October to December.

3. *Local Winds.* Inshore or sea breezes during the day and offshore or land breezes during the night are frequent on the coast in summer. They are not necessarily distinct or regular, as conditions are not always favourable to their production, and in any case what is observed is the resultant effect of the general wind blowing over the district and the sea breeze. As the day goes on the sea breeze tends to veer with the sun and may finally blow along the coast instead of across it.

4. Comparison of the number of days of *fog* at different stations is difficult because of the presence of the personal factor in estimating fog. An area of maximum fogginess includes Oxford and London and stretches eastward to Germany. Stations on the extreme western coasts have a summer maximum (sea fog), but the inland regions of the British Isles generally have a maximum in autumn and winter (land fog). At some places, especially those under the influence of both types of fog, there is a fairly equal distribution throughout the year.

5. Table 1 shows for four air-stations the average percentage number of occasions of fog (range of visibility below 1,100 yards) at certain hours

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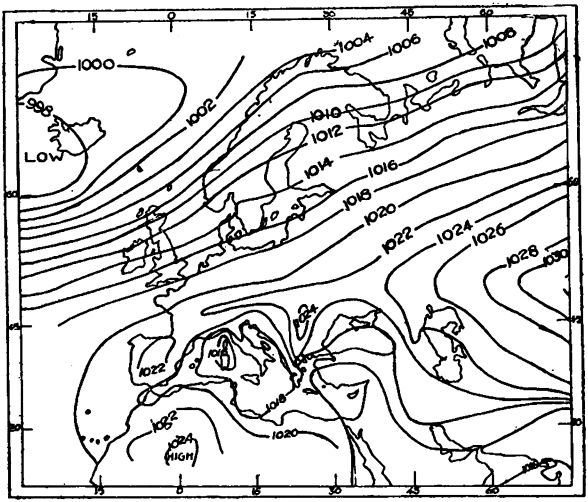

FIG. 105.—Pressure distribution in millibars—January.

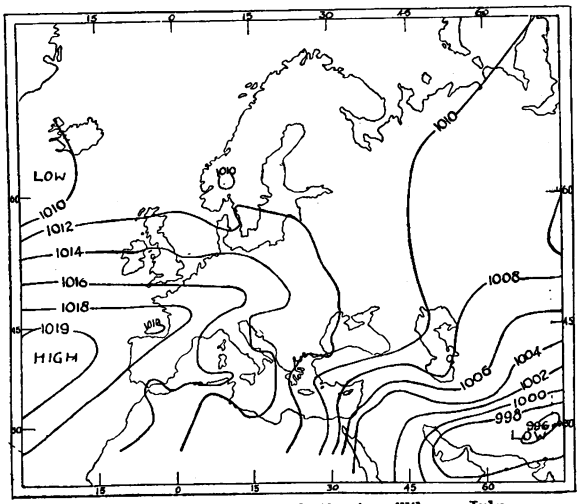

FIG. 106.—Pressure distribution in millibars—July.

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during the four winter months and four summer months respectively. The averages are based on reports for the years 1921 to 1923.

Table 1. Average number of Fogs (Range of Visibility below 1,100 yards) in 100 days.

	November to February.			May to August.		
	7h	13h	18h	7h	13h	18h
Croydon - - -	10	7	11	1	0	0
Lympne - - -	12	5	4	3	1	2
Calshot - - -	4	2	3	1	0	0
Cranwell - - -	8	4	6	1	0	0

6. Generally speaking south-west winds are the foggiest on the west coast of England throughout the year, except in Lancashire, where the industrial area to eastward makes easterly winds the foggiest, especially in winter. On the South coast there is not a great deal of difference with winds of different direction, but on the east coast there is a tendency for west or south-west winds to be foggiest in winter and north-easterly winds in summer. In the interior the great majority of fogs occur with calms or light winds.

7. *Gales* are infrequent at any distance from the sea, except in exposed localities. On the coast a gale is recorded on the average on about one day a week in winter but only two or three times in each summer, and the summer gales are in addition much more transitory. Table 2 gives the average number of days of gale in a month for four districts, the first three of which (Scotland north-west, Ireland north-west and Irish Sea) are the most windy regions of the British Isles.

Table 2. Average Number of Days of Gale in a Month.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Scotland NW. -	6	5	3	2	1	0	0	1	2	3	5	6
Ireland NW. -	8	6	5	3	1	1	1	1	3	5	8	8
Irish Sea -	6	5	5	2	1	1	1	1	2	4	6	6
England SE. -	3	3	2	1	0	0	0	1	1	3	4	4

8. The great majority of the gales experienced in the British Isles are connected with barometric depressions. As the favourite track of these depressions passes north-west of the British Isles, it follows that a large proportion of the gales blows from between South and West-North-West. If the depression has a more or less circular form and passes fairly close to the British Isles on the north-west, the usual course is for the wind to commence from south and veer gradually through south-west to west or even north-west. If the depression is more distant the wind may remain between south-west and west-south-west throughout. In some cases, however, "secondary depressions" or "line-squalls" may be developed south of the main depression, and these may give rise to a gale with a sudden shift of wind from south or south-west to north-west, with a heavy squall and often a thunderstorm at the moment of the change. In the past these squalls have been very dangerous to shipping and they should be avoided by aircraft if possible.

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9. In England easterly winds are in general of less force than those from south-west. When pressure is high over Iceland, however, a deep depression sometimes passes up the Channel, causing sudden easterly gales of short duration on the south and south-east coasts. In the same way, if pressure rises rapidly after the passage of a depression across the British Isles, northerly gales may result, which may continue for one or more days. Northerly gales on the east coast are also caused by depressions moving southward down the North Sea.

10. *Rain* in England is rarely heavy enough to interfere seriously with aviation, except in the brief thunderstorms of summer, in which the air is in a disturbed condition.

The rainfall is greatest near the west coasts, especially in mountainous districts, and least in East Anglia and the Thames Estuary. There are no definite wet or dry seasons, but a fairly uniform distribution of rainfall throughout the year, rising to a slight maximum in one month in one part and in another month at another, but never very markedly. The heaviest rainfall in any one year may occur in any month, but of course it does so less frequently in the months with the smallest average rainfall. In London, south-east England, and the Central Plain, October is the wettest month; August and October to December over a large part of Scotland; and August and December over a considerable portion of Ireland. On the whole, about 20 per cent. of the rainfall for the entire year falls in spring; in summer the Atlantic Coasts are relatively dry while Eastern Britain has over 25 per cent. of its annual rainfall. In autumn the extreme West is subject to frequent depressions which make this the rainiest season. The distribution throughout the year is so uniform, however, that autumn rainfall nowhere exceeds 40 per cent. of the annual fall. The annual number of raindays, including days on which rain falls for a few minutes only, exceeds 200. As a rule the average rainfall in a rainday is greater in summer and autumn than in winter. The heaviest falls inland are almost without exception of a thunderstorm character and occur in summer; but on the western coasts autumnal cyclonic rains give the heaviest falls.

11. *Thunderstorms* are of two classes. By far the most numerous are those of the summer type due to the heating of air by contact with a considerable land area. The maximum prevalence is in Eastern England. Favourable upper air conditions are necessary for the development of thunderstorms, the most important condition being a high rate of fall of temperature with altitude. The maximum frequency is in the afternoon or early evening. Individual storms are of small extent, and the aviator can usually see them from a distance and avoid them. The winter type is almost confined to the western coasts, and the storms are not usually isolated, but develop along the front of a "line-squall" which may extend 100 miles or more. They travel in an easterly or south-easterly direction, and though actual storms may not form a continuous line the disturbed air does, constituting a dangerous and often impassable barrier for aircraft.

12. Heavy *Snow* is comparatively rare in the south of England, but may be a distinct disadvantage in winter in the north, where it may lie thickly on the ground for weeks. Falling snow often limits the visibility to a few yards.

13. The distribution of *cloudiness* is on the whole similar to that of rainfall. Taking the entire year the region of maximum cloudiness is the North-west of the British Isles; that of minimum cloudiness the southern part of the east coast and the extreme south-easterly and southern coasts of England. In January the north-west portions of Ireland and Scotland are among the cloudiest areas; Eastern Britain is markedly less cloudy, averaging under 7/10th of sky covered. There is a definite minimum of cloudiness in May and June, when the average in Southern and Eastern England is 6/10th. Cumulus cloud reaches its maximum in June and July.

Upper Air Conditions:

14. *Winds and Temperatures of the Free Air.* While winds at the surface are generally inclined to the isobars, blowing inwards towards the low pressure at an angle of about 30°, in the free air they increase in velocity and approach the isobaric direction, until at about 1,500 feet

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the actual wind approximates to the "geostrophic" wind, which is the wind calculated from the pressure gradient. At a great height, say five miles, the wind whatever its surface direction tends to become westerly. The falling off of easterly winds with increasing height is most rapid in autumn and winter, least rapid in summer. As a general rule, cirrus, the highest of all clouds, moves from the west in temperate latitudes. Thus an east wind quickly decreases with height and is replaced by a westerly current, while a west wind merely increases in velocity upwards. Usually the maximum velocity is reached at an elevation of about 35,000 feet. Mean temperature falls off rapidly upwards to about 35,000 feet, the average rate being about 1° F. in 300 feet. The seasonal temperature range is still considerable up to about 30,000 feet, but the diurnal range has practically disappeared at a height of 7,000 feet. The relative humidity generally increases from the surface to the lower cloud level, about 3,500 to 6,000 feet, and then decreases.

15. Table 3 shows the frequency and average velocity of geostrophic winds in London for each month. The preponderance of west winds throughout the year is very noticeable. Other interesting points are the constancy of north winds throughout the year and the diminished frequency of east winds in summer. The greatest velocities occur with west winds. The column "indeterminate" refers to calms and to miscellaneous occasions when the direction of the geostrophic wind cannot be dete mined.

Table 3. Frequency and mean velocity of Geostrophic Winds at London 1881–1915.

F=percentage frequency; V=velocity in m.p.h.

Wind from :—

	North.		East.		South.		West.		Inde-terminate.
	F.	V.	F.	V.	F.	V.	F.	V.	F.
January - -	13	34	11	29	21	30	38	36	17
February - -	16	34	12	30	17	30	37	35	18
March - - -	18	34	12	30	15	31	35	35	20
April - - -	17	25	21	26	15	26	30	29	17
May - - -	17	24	17	26	14	24	26	28	26
June - - -	17	23	14	24	11	21	29	25	29
July - - -	17	21	7	19	13	20	39	24	24
August - -	14	23	7	21	16	23	42	26	21
September - -	16	24	13	23	19	23	30	26	22
October - -	17	29	12	28	24	27	30	32	17
November - -	15	31	12	30	21	29	34	26	18
December - -	13	33	9	28	25	32	38	36	15
Year - - -	16	28	12	26	18	27	34	25	20

Forecasting :

16. Whenever possible, forecasts should be obtained from the Meteorological Office Headquarters, Air Ministry, or from a local Meteorological Officer. In an emergency however information of value can often be obtained by local observation, especially if the general pressure distribution is known beforehand. For forecasting gales the barometer and wind should be watched carefully. If the barometer is falling steadily and the wind is from south increasing in force, a strong wind or gale is to be anticipated. If the wind persists from south, either the depression itself or a line-squall is approaching directly, and heavy rain is likely to be experienced, followed by a sudden shift of the wind to northwestward with a squall. If the wind backs to south-east and east, the depression is passing to the southward and heavy rain or in winter snow is probable, while the wind will continue to back until it becomes north-east. Squalls are not probable and the wind is unlikely to exceed forty miles per hour.

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If, as will most often happen, the wind backs towards south-west, the depression is to the northward; if the backing is not accompanied by an increase of force, little danger is to be apprehended, but if the force increases steadily as the barometer falls, great caution should be shown, as either the centre is not far off or the depression is severe and in either case a gale is likely to ensue. After the barometer has again begun to rise and the wind has veered to west or north-west, it often becomes stormier in character and the temperature falls considerably. Under these circumstances there may be several repetitions of the squall which marked the passage of the lowest barometer (trough); but ultimately as the rise continues, fair weather will be re-established.

17. It should be borne in mind that different depressions move at very different rates. A storm which approaches rapidly is likely to move away rapidly, while one which approaches slowly is likely to make its presence felt for a considerable time. In this sense there is much truth in the ancient proverb:—

"Long foretold, long last,
Short notice, soon past."

18. It has also to be remembered that depressions often follow one another along the same track at intervals of a day or two, separated by a day of brilliantly fine weather; this is the meaning implied in the general outlook "unsettled." The intervening fine day must not be taken as an earnest of lasting fine conditions. In addition to the barometer, clouds are often of use in local forecasting. The development of filmy cirrus clouds, thickening until they form a thick sheet of cirro-stratus, is a useful indication that a depression is approaching. Halos, which are formed by the sun or moon shining through cirro-stratus, are a similar indication of approaching rain.

19. The best indication of an approaching thunderstorm is the development of an "anvil" cloud or cumulo-nimbus, especially if filaments of "false cirrus" are seen issuing from its sides or summit.

20. The forecasting of fog is difficult, and in the case of sea-fog it is practically impossible without a synoptic chart unless local prognostics are well-known. Sea fog is always to be looked for when a warm moist air current blows over a region where the sea surface is relatively cold.

In winter, when anti-cyclonic conditions—high pressure and calms or light winds—become established, inland fog may be expected to set in towards evening if the sky is clear. Such fog may persist for long periods. Fogs also occur when mild southerly winds set in after a spell of cold weather. In spring, summer and autumn the wet and dry bulb thermometers form a useful guide. The development of mist or fog depends on the air becoming super-saturated with moisture. In this condition the wet and dry bulbs read alike. Suppose then that with a clear sky and light winds the wet bulb, a few hours before sunset, reads nearly as high as the dry bulb. Then as the temperature falls the capacity of the air for holding moisture diminishes, the air becomes saturated, and mist or fog develops. A clear sky is generally necessary to enable the air and earth to radiate away heat and so cool sufficiently; calm or light winds are necessary, because strong winds mix up the different layers of air and prevent sufficient cooling for saturation.

Major G. I. Taylor has found that at Kew it is reasonably safe to forecast "no fog" during the night if the wind at a height of 65 feet above ground at 20 h. exceeds 5½ miles per hour. Still useful, though less exact, is the forecast of "no fog" when the wind at 18 h. exceeds 9 miles per hour. This does not mean, however, that when the wind is less than these velocities fog always forms; whether it will do so or not depends on the temperature and the amount of moisture present in the air. Major Taylor has put his results into the form of a self-explanatory diagram (Fig. 107), which can be taken as applying to the interior of England. The diagram may be used conveniently for predicting whether fog is likely to appear on an aerodrome during the night. The wet and dry bulb readings are taken at 20 h. If the wind is less than 5½ m.p.h., and if the sky is not more than half-clouded, then a fog is probable if the point on the diagram which represents the state of the air at 20 h. lies below the line. If the point lies above the line, fog is

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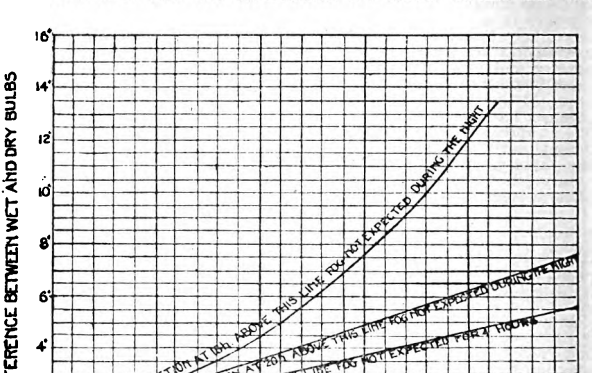
improbable. If the point lies close below the line, *i.e.*, if there is still a difference between the wet and dry bulb readings, but not enough to ensure the absence of fog, fog is probable, but will not appear for some considerable time after the observations are taken. A line has been



AIR TEMPERATURE.—FOG PREDICTION DIAGRAM.

FIG. 107.

drawn on the diagram which indicates roughly the difference which is necessary in order that the fog may not appear for about four hours. If the wind at 20 h. is nil, *i.e.*, dead calm, there is considerable risk of fog or mist, whatever may be the thermometer readings. It may sometimes be convenient to make a forecast at 18 h. instead of at 20 h., though the latter is more likely to be correct. To allow for this contingency a third line has been drawn on the diagram above the 20 h. line.

A meteorological summary for Kew Observatory is shown on page 241.

45. METEOROLOGICAL NOTES.—EGYPT AND THE MEDITERRANEAN.

Surface Conditions :

1. The climate of Egypt is sub-tropical, with a mild winter in which rain occasionally falls, and a hot, dry summer. Except in the neighbourhood of Alexandria, Egypt is in fact a natural desert, which is only fertilised by Nile floods.

2. *Pressure and Winds in the Mediterranean.* In the Eastern Atlantic between the Azores and Madeira, lies a permanent high-pressure area which is centred on about 30° N. in winter and 40° N. in summer. The anticyclonic area extends eastward as a belt of genera high pressure, but the distribution is greatly modified in winter by the presence of the warm Mediterranean. In January there is a centre of high pressure over Spain, continuing across the Alps to South Russia. Pressure is also high over North Africa; between these two belts, which both exceed 1,024 mb. in places, the pressure is relatively low over the Mediterranean, being below 1,018 mb. generally and below 1,016 mb. in the Gulf of Lions. This low pressure forms a favourite track for depressions. Some of these approach from the Atlantic, either by way of southern France or more

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METEOROLOGICAL TABLE FOR LONDON (KEW OBSERVATORY).

Lat. 51° 28′N. Long. 0° 19′W. Height above M.S.L. 18 feet.

Month.	Temperature. Record. Max.	Temperature. Record. Min.	Relative Humidity.‡	Cloud Amount. Scale 0–10.‡	Precipitation. Monthly.	Precipitation. Record in Day.	Days of Precipitation.§	Days of Snow.	Days of Frost.	Days of Fog.	Days of Strong Wind or Gale.	Days of Thunder.	Wind.‡ Prevailing Wind Direction.	Wind.‡ Percentage of Observations from :— N.	E.	S.	W.	Calm.	Upper Wind. (Geostrophic Winds.) Percentage of Observations from :— N.	E.	S.	W.	Calm or Variable.
	°F.	°F.			mm.	mm.																	
Jan.	57	9	85	7·4	45	41	16	3·3	15·5	6		0·1	S.W.	15	15	27	30	13	13	11	21	38	17
Feb.	62	11	82	7·4	39	23	13	3·0	15·2	4		0·1	S.W.ly	13	18	30	28	11	16	12	17	37	18
Mar.	68	17	79	7·0	43	24	14	3·4	15·5	3		0·7	S.W.	21	17	23	29	10	18	12	15	35	20
Apr.	80	27	75	6·6	37	30	13	1·0	12·7	2		1·1	Var.	26	14	18	30	12	17	21	15	30	17
May	84	30	73	6·5	44	45	12	0·1	3·9	0·6		2·2	Var.	22	26	19	24	9	17	17	14	26	26
June	88	37	73	6·6	55	60	12	0·0	0·8	0·7		2·3	Var.	19	14	25	36	6	17	14	11	29	29
July	90	43	73	6·7	55	58	12	0·0	0·0	0·7		3·0	S.W.	22	13	24	33	8	17	7	13	39	24
Aug.	94	41	76	6·5	57	46	13	0·0	0·0	1		3·0	S.W.	16	11	29	32	12	14	7	16	42	21
Sept.	92	31	79	6·3	48	40	12	0·0	1·8	3		1·1	Var.	19	17	21	29	14	16	13	19	30	22
Oct.	83	25	85	6·8	69	36	17	0·0	8·1	8		0·6	Var.	17	14	20	25	24	17	12	24	39	17
Nov.	63	20	86	7·1	56	34	16	0·6	13·8	7		0·1	S.W.ly	12	14	27	34	13	15	12	21	34	18
Dec.	58	11	86	7·4	58	39	17	1·9	13·5	5		0·1	S.W.	13	9	33	35	10	13	9	25	38	15
Year	94	9	89	6·9	606	60	167	13	100·8	41		14·2	S.W.	18	15	25	30	12	16	12	18	34	20
Years	1871–1921		1871–1915	1841–1890	1881–1915			1912–1920	1908–1920	1906–1920		1886–1915	1881–1915						1881–1915				

‡ Mean of observations at :—9h. and 21h. up to 1908.
9h., 15h., 21h. from 1909.

§ 0·2 mm. or more.

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rarely southern Spain; but a large number are originated in the Mediterranean itself, especially in the Gulf of Lions. The majority move eastwards across Sardinia, southern Italy, Greece and the Aegean, while the coast of Africa is favoured by others. Some pass north-eastward into the Black Sea, others through the Levant to Syria and ultimately to Northern India, while the remainder die out in the eastern Mediterranean. These depressions are small compared with those of more northern latitudes, but they are sometimes deep and often associated with heavy rain and gales. The resulting winds are variable, but prevailingly E. or N.E. in the north and W. or S.W. in the south. Pressure often rises rapidly in the rear of a depression, causing strong northerly gales which spring up very suddenly. The westerly winds rarely penetrate more than 100 miles from the African coast, and in the Nile valley northerly winds blow continuously.

3. By April the pressure distribution has become uniform and depressions rarely trouble the south-eastern Mediterranean. With high pressure east of the Nile, the passage of a depression in the Aegean gives rise to strong south-easterly dust-laden hot winds known as "Khamsin" (*see* below), but the prevailing winds in North Africa are northerly.

4. In July pressure falls steadily from the Azores maximum (1,020 mb.) to a minimum over the Persian Gulf (996 mb.), causing N. or N.W. winds over the whole area. These winds are dry, and the meteorological conditions being stable, little or no rain falls. Over most of the Mediterranean the winds are of little strength, but they are more vigorous over the Levant, Lower Egypt and Palestine, occasionally reaching gale force over the Aegean, especially during the day. In October the pressure distribution begins to assume its winter character.

5. The *Khamsin* of Egypt is a hot dust-laden southerly wind remarkable for its extreme dryness, a relative humidity of 2 per cent. having been recorded at Cairo and 13 per cent. even at Alexandria. The temperature has risen to 109° F. at Cairo. Khamsin occurs several times a month in March, April and May, less frequently in June and September, and rarely at other times. It usually begins a few minutes after sunrise, reaches its greatest intensity about 13 h., and ceases towards evening; it may be accompanied by sudden sandstorms in which the wind attains a velocity of 35 m.p.h. or more. These storms set in with less than an hour's warning. Attention must also be called to a cold north-east wind which blows in winter from the mountains of Sinai down the Gulf of Aquaba, sometimes with great force. Land breezes are not well developed on the coast of Egypt; instead the nights and early mornings are calm and the sea breeze springs up about 10 h., increasing to about 20 m.p.h. in the afternoon and dying down again towards evening. At Cairo the mean wind direction for the year is N.E. in the early morning, backing steadily till at 15 h. it blows from N.N.W. After 15 h. it veers till at midnight it is again N.E. In January there is little prevailing wind, and in consequence the change in direction is very great varying from E.S.E. at 9 h. to between N and N.W. at 13 h. On the other hand in July the change is slight from N.N.E. in the morning to N.N.W. in the afternoon. The diurnal variation of velocity at Helwan is shown in Table 4.

Table 4. Diurnal variation of wind velocity at Helwan, Cairo, mi/hr.

Hour.	2.	4.	6.	8.	10.	12.	14.	16.	18.	20.	22.	24.	Mean.
Winter - -	7	7	7	*6*	7	10	11	**11**	10	**9**	8	8	8·3
Spring - -	10	8	*8*	8	9	12	13	14	14	15	**16**	13	11·8
Summer - -	9	7	*7*	9	9	12	13	14	15	**17**	15	12	11·7
Autumn - -	9	8	*7*	7	9	12	13	14	12	**14**	14	11	10·8

6. The distribution of *Mist* and *Fog* in the Mediterranean is extremely local but Table 5 gives some idea of the general distribution.

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Table 5. Percentage frequency of mist and fog.

Month.	* Western Mediterranean per cent.	† Eastern Mediterranean per cent.	Egyptian coast per cent.	Cairo per cent.
January	2–6	3	2	3
February	6–10	4–6	3	2
March	8–15	5–7	2–3	½
April	12–20	8–13	5–8	0
May	15–25	15–20	10–15	0
June	20–33	20	10–15	0
July	20–30	10–15	5–10	0
August	15–30	10–15	6	0
September	10–20	5–12	2	0
October	5–10	3–4	2	½
November	3–10	3–5	2	1
December	2–5	3–6	2	2

* The higher values occur near Gibraltar and in the Gulf of Lions, the lower on the Algerian coast.

† The frequency recorded at Athens is much higher.

7. Fogs are limited to the early morning, and rarely reach a frequency of 1 per cent. Mists are most frequent in the morning, especially on the coast, but occasionally last all day. At Cairo morning mist occurs on three to five days a month between November and February and very occasionally in other months; all the mists were recorded at 8 h. but generally disappeared by 9 h.; about twice a year they last till 11 h., and they are never seen after noon. Their thickness is about 100 to 200 feet, in exceptional cases 500 feet. It is often impossible to see the ground from a height of 50 feet. In the summer months visibility is often limited by the dust haze, and mirage may also interfere, but under favourable conditions visibility is very good.

8. The *Rainfall* is extremely slight, averaging eight inches a year at Alexandria and less in all other parts of Egypt. The interior is practically rainless. On one occasion Alexandria was visited by a water spout, and 11 inches of rain fell in a short time. *Snow* is unknown in Egypt, and *Thunderstorms* are rare, averaging only five a year at Alexandria and four at Cairo; they may be accompanied by hail.

Upper Air Conditions :

9. *Upper Winds.* Over the Mediterranean in general the prevailing N. or N.W. winds fall off rapidly with height and are replaced by W. winds. The local winds, Bora, Khamsin, etc., are also shallow, rarely affecting the air above 3,000 feet. At Alexandria pilot balloon observations in December 1918 to May 1919 showed that the frequency of westerly winds increases with height, while that of easterly winds falls off. There is a tendency for westerly winds to increase in velocity with height in spring, but not in winter; otherwise the changes of velocity are slight. Westerly winds predominate at all heights in winter, north-westerly winds in summer.

10. Upper air investigations at Cairo show that at a height of 2,000 to 3,000 metres (6,000 to 10,000 feet) the N. and N.W. winds of the Nile Valley are usually overlaid by westerly winds. The mountains of the Sinai peninsula (6,000 feet) are high enough to project into this westerly current. The velocity in the free air at 6,000 feet averages 18 mi/hr.; but when a depression is passing to the northward, velocities of 35 mi/hr. occur, though rarely.

11. During the summer months the intense heating of the ground produces strong convection effects during the day; these begin to appear shortly after sunrise, and by 10 h. have extended to a height of about 4,000 feet, increasing to 7 000 or 8,000 feet by evening. In the middle of the day there are often strata and pockets of air at different temperatures,

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making flying very bumpy up to 8,000 or 9,000 feet. The height of a sandstorm rarely exceeds 5,000 feet; the usual height is 3,000 feet.

Forecasting :

12. One day in Egypt is very like another especially when one leaves the Mediterranean coast, and regular forecasts are hardly necessary, especially in summer. In Cairo they can be obtained from the Meteorological Officer, R.A.F. The chief danger is the Khamsin and associated sandstorms; this occurs with high pressure east of Egypt and a depression approaching from the West. The first indication is a fall of the barometer, a rapid decrease of humidity as the dry air arrives from the South, and the appearance of high light cirrus clouds. Under these circumstances the Khamsin will probably develop next day.

A table for Cairo (Helwan) is shown on page 245.

46. METEOROLOGICAL NOTES.—MESOPOTAMIA OR IRAQ.

Surface Conditions :

1. The climate of Mesopotamia is dry, with a short cool winter and a long hot almost rainless summer; the difference between day and night temperatures is large.

2. *Pressure and Winds.* In winter the country lies on the southern edge of the great Asiatic high pressure area, and the prevailing winds are northerly; but the regular course is disturbed three or four times a month by cyclonic depressions passing eastward from the Mediterranean (*see* Egypt) bringing some rain, mist and fog. During the passage of these depressions gusty winds of gale force occur, but rarely, and chiefly from S.E. In March and April these depressions cease to give steady rain, but there is a development of thunderstorms associated with sudden westerly squalls of gale force. In May the hot weather sets in and lasts until September. During this season pressure is low over Southern Persia and Baluchistan, and persistent north winds, originating in the mountains of Asia Minor and Kurdistan, sweep down the valleys of the Tigris and Euphrates. During the months of June, July and August a moderately high wind blows on most days, with occasional periods of light breezes and very high temperature or occasional bursts of very high winds with a drop in temperature. These are dry dusty winds known as Shamal, which reach gale force on one day a month on the average; they occur in the rear of depressions passing across Asia Minor. The average wind velocities, however, are low throughout the year, as shown in the following table for Baghdad :—

Table 6. Mean wind velocity (mi/hr.) at Baghdad, 1908-14.

Jan.	Feb.	Mar.	Apr.	May.	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.
5·7	6·6	6·9	6·5	6·5	9·1	9·6	8·3	6·3	5·6	5·2	5·3

3. The *diurnal variation* of wind direction is well marked. As the day advances, the northerly winds at first tend to veer slightly, but later back towards west, becoming W. or S.W. in the afternoon. East winds often veer to S.E. or S. The diurnal variation of velocity is also marked, the average at 10 feet above the ground ranging from 5 mi/hr. during the night to 10 mi/hr. between 11 h. and 15 h. It is most marked in summer, when there is a corresponding variation in dust-storms, which usually start about 9 h., so that aeroplanes ascending in the early morning run the risk of landing in a dust storm. A table of wind frequency for Baghdad is shown on page 246.

4. The amount of *cloud* is small, especially in summer, when the air is very dry. Between November and April there are periods of rain and low cloud, increasing in frequency with proximity to the Persian and Kurdish hills. The rainfall is only a few inches and occurs on 20 to 30 days a year. *Snow* is recorded about once in ten years on the plains. At Mosul in 1911 it

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METEOROLOGICAL TABLE FOR CAIRO (HELWAN).

Lat. 29° 52′ N. Long. 31° 20′ E. Height above M.S.L. 379 feet.

Month.	Temperature. Record. Max.	Temperature. Record. Min.	Relative Humidity.‡	Cloud Amount. Scale 0–10.‡	Precipitation. Monthly.	Precipitation. Record in Day.	Days of Precipitation.§	Days of Snow.	Days of Frost.	Days of Fog.	Days of Strong Wind or Gale.	Days of Thunder.	Wind. Prevailing Wind Direction.	Wind. Percentage of Observations from :— N.	E.	S.	W.	Calm.	Upper Wind. Percentage of Observations from :— N.	E.	S.	W.	Calm or Variable.
	°F.	°F.	%		mm.	mm.																	
Jan.	83	35	58	4·5	9	—	3	0		5		0·3	N.E.	36	24	19	18	3					
Feb.	84	37	50	4·1	5	—	2	0		3		0·3	Var.	31	21	20	25	3					
Mar.	96	38	46	3·8	6	—	1	0		1		0·5	N.	45	21	14	18	2					
Apr.	108	42	41	3·3	6	—	1	0		0·3		0·3	N.	49	21	12	17	1					
May	111	52	38	2·8	2	—	0·1	0		0		0·3	N.	59	18	5	17	1					
June	110	55	42	0·9	0	—	0	0		0		0·1	N.	67	14	1	16	2					
July	108	63	46	0·9	0	—	0	0		0·6		0	N.N.W.	68	5	1	24	2					
Aug.	104	63	50	1·0	0	—	0	0		0		0·05	N.	74	5	0	20	1					
Sept.	106	58	54	0 9	0	—	0	0		0·4		0·1	N.	73	13	1	12	1					
Oct.	105	55	53	2·6	0	—	0	0		1		0·8	N.	62	22	3	12	1					
Nov.	94	42	57	·3·1	3	—	1	0		3		0·9	N.E.	44	27	13	14	2					
Dec.	84	34	58	4·0	4	—	1	0		4		0·5	N.E.	36	24	21	17	2					
Year	111	34	49	2·7	35	—	9	0		18			N.	54	18	9	17	2					
Years	1904–10				15 yrs.		15 yrs.			1904–10		45 yrs.	1904–12										

‡ Mean of observations at :—Hourly Cloud at 8, 11, 14. 17, 20 h.

§ 0·2 mm. or more.

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lay on the ground from January 20th to February 8th. *Fog* occurs during anticyclonic weather in the winter months. It usually commences in the early morning and clears away during the forenoon, but occasionally persists throughout the day. Table 7 shows the frequency :—

Table 7. Number of foggy days per month in Iraq.

Place.	No. of Years.	Oct.	Nov.	Dec.	Jan.	Feb.	March.
Baghdad -	20	0·05	0·7	2·0	2·8	0·6	0·05
Basrah -	8	0·6	0·6	1·8	2·1	0·3	0
Ahwaz -	4	0·4	0·4	1·2	2·8	1·2	0·2
Samarrah -	1	0	0	3	3	0	1
Qurnah -	1	0	1	3	3	0	0

5. *Thunderstorms* occur chiefly in the spring months. These generally appear in the evening or at night, advance from the west, and are preceded and accompanied by very squally winds.

Table 8. Number of thunderstorms per month.

Place.	No. of years.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.
Baghdad -	25	0	0	0	1	0	1	1	2
Babylon - -	5	1	2	2	1	2	2	5	5
Samarrah -	1	0	0	0	3	1	5	8	5

6. *Mirage* occurs in summer, and interferes with visibility. *Hail* is of occasional occurrence with hailstones up to 1½-inch diameter. It should be noted that the very high temperatures during the day in summer, with the accompanying decreases of air density and air viscosity, often lead to a loss of efficiency, so that some engines refuse to take the aeroplane off the ground. Engine trouble is also frequent at this season.

7. *Floods.* The rivers reach their highest level in March, April and May when they may rise rapidly.

Upper Air Conditions,

8. *Upper Winds.* Table 9, based on observations at Baghdad from 1916 to 1918, gives the direction and average velocity of the winds up to 9,000 feet.

Table 9. Frequency (per cent.) and velocity of upper winds at Baghdad. October to March.

Direction.	Height above ground in feet.					
	200.	1,000.	3,000.	5,000.	7,000.	9,000.
Calm -	5	3	6	4	2	1
N. - -	15	21	11	16	19	14
N.E. -	7	5	6	5	4	5
E. - -	8	5	7	5	7	5
S.E. -	19	19	11	7	4	2
S. -	3	6	13	14	10	8
S.W. -	3	5	5	9	13	18
W. -	7	6	11	15	15	24
N.W. -	33	30	30	25	26	23

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April and May.

Calm -	4	1	3	4	1	4
N. - -	33	30	23	12	6	4
N.E. -	11	14	12	5	0	0
E. - -	8	8	4	3	0	0
S.E. -	14	9	12	3	9	2
S. - -	1	9	8	13	10	6
S.W. -	2	9	7	15	24	27
W. -	12	5	10	9	31	39
N.W. -	15	15	21	26	19	18

June to September.

Calm -	1	2	2	4	3	2
N. - -	40	46	35	27	21	22
N.E. -	12	13	9	6	4	2
E. - -	3	4	4	2	1	1
S.E. -	1	2	2	3	3	3
S. - -	2	1	3	5	4	6
S.W. -	2	1	0	2	6	7
W. -	4	3	5	7	14	20
N.W. -	35	28	40	44	44	37

Mean Velocity in mi/hr.

Season.						
October–March	11	13	12	12	14	15
April–May	12	17	15	15	17	20
June–Sept.	16	22	19	17	16	17
Year -	13	17	15	14	15	17

9. It should be noted that these observations were made in the early morning, which accounts for the maximum of velocity at 1,000 feet in each case. The table shows that apart from this there is a slow rise in velocity up to 9,000 feet except from June to September. There is a marked decrease in the number of easterly winds and increase in the number of westerly winds as higher levels are attained, just as in England, so that at 9,000 feet 69 per cent. of the winds blow from S.W., W. or N.W. and only 9 per cent. from N.E., E. or S.E. During the hot season convection is very strong, causing bumpy and unpleasant flying, which extends to 6,000 or 7,000 feet.

Forecasting :

10. In winter the changes of weather are due to the passage of barometric depressions. These move from west to east, and reach Mesopotamia about two days after passing Egypt or Cyprus. Warning of their approach can be obtained from the Meteorological Officer, R.A.F., Baghdad. The local prognostics are a fall of the barometer (after making allowance for the semi-diurnal variation, which reaches maxima between 9 and 10 h., and at 22 h., and minima at 3 to 4 h. and 16 to 17 h.), and a freshening wind from S.E. or S. Rain or cloud is likely to follow, and when the barometer ceases to fall, the wind will change to north-west and become squally; it may reach gale force. In spring the passage of such a depression is likely to bring thunderstorms and squalls. When the

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barometer becomes high and steady, morning mist or fog may be expected in winter. In summer, as in Egypt, the weather is persistently similar day after day, with a freshening of the wind during the morning and frequently a dust storm after 9 h. Clouds, rain, thunder and fog are unknown in summer, and practically the only variation of the barometer is the regular semi-diurnal wave alluded to above.

47. METEOROLOGICAL NOTES.—INDIA.

1. The large area occupied by India gives room for a great variety of climates, ranging from desert to the heaviest rainfall in the world. Over the country as a whole there are three seasons, the "cold weather" from November to March, with northerly winds, some rain in the north-west and in eastern Ceylon but fine over most of the country; the "hot weather" from April to the middle of June, with fine but dusty weather and light winds, and the "monsoon," from about mid-June to mid-September, with south-westerly winds and heavy rain.

Surface Conditions :

2. *Pressure and Winds* (Fig. 108) shows the average pressure distribution at 8 h. in January. Pressure is highest in the north-west, being 1,021 mb. (30·15 in.) over Kashmir, and falls southwards to below 1,014 mb. (29·95 in.) in Ceylon. The winds are light and chiefly from N. or N.W. in the plains, Bengal and Burmah, but from E. or N.E. in the Deccan. By March pressure has become almost uniform and the winds at 8 h. are light and irregular. In April pressure is lowest in the north (1,007 mb. or 29·75 in.) and highest over Ceylon (1,011 mb. or 29·85 in.); the prevailing winds are now from W. on the west coast, from S.W. on the east coast, and irregular over the Plains; this distribution is intensified in May. During the hot season strong *land and sea breezes* are developed on the coast. At midday the wind blows directly inshore but later in the day it veers with the sun and blows parallel to the coast in the evening. In June pressure is below 999 mb. (29·5 in.) in the Indus valley, rising to 1,009 mb. (29·8 in.) over Ceylon; the winds are steadily from W. over the Deccan and the whole west coast as far as Karachi, from S.W. or S. over Burmah and Bengal, turning to S.E. along the southern side of the Himalayas. In this month the monsoon generally appears. In July (Fig. 109) the monsoon reaches its maximum intensity, but the pressure and wind distribution changes little until the end of September. October is a transition month with uniform pressure and light variable winds, while November and December resemble January.

3. The setting in of the rainy season is known as the "Burst of the monsoon." The preceding weather in the interior is characterised by great heat and dryness, visibility limited by dust haze and strong winds during the day alternating with calms at night. Then a great stream of moist air from the west sweeps across, accompanied by very severe thunderstorms. The monsoon rains begin in Ceylon, Burmah and the southernmost parts of India in the last week in May; their progress is shown by the following table :—

Table 10. Duration of South-west Monsoon.

District.	Average date of Beginning.	Average date of Ending.	Duration, days.
Bombay	June 5	Oct. 15	133
Central Provinces	,, 10	,, 15	128
Central India	,, 15	Sept. 30	108
Rajputana	,, 15	,, 20	98
Bengal	,, 15	Oct. 31	139
Bihar	,, 15	,, 15	123
North-west Provinces and Oudh	,, 25	Sept. 30	98
Eastern Punjab	July 1	,, 15	77

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4. Severe thunderstorms and heavy rain are frequent throughout the rainy season, alternating with occasional spells of two or three days of

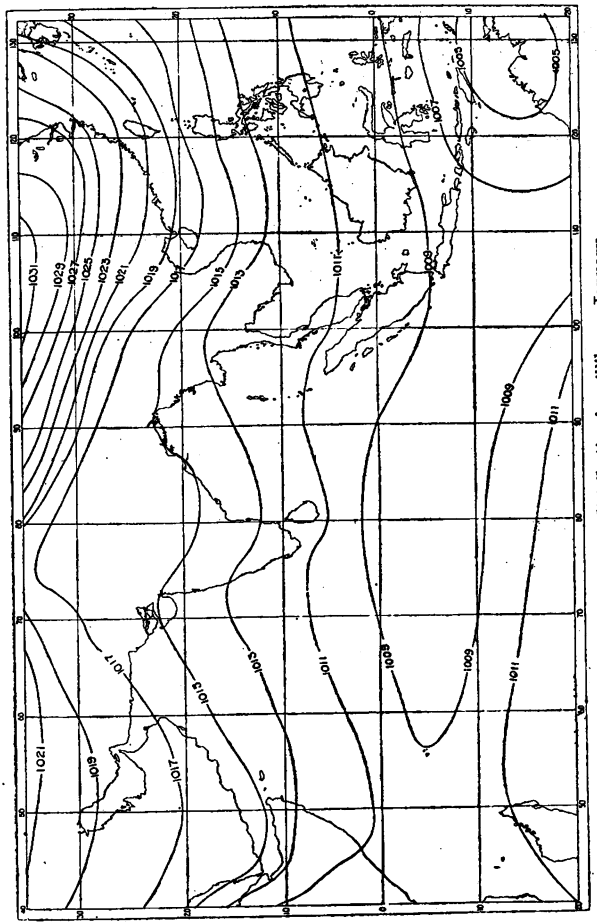

FIG. 108.—Pressure distribution in millibars—January.

fine weather. The distribution of mean annual *rainfall* is largely governed by the relief in connection with the prevailing monsoon winds. The

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regions receiving over 2,500 mm. (100 inches) a year include the west coast from Bombay to Cochin, central Ceylon, the eastern Himalayas

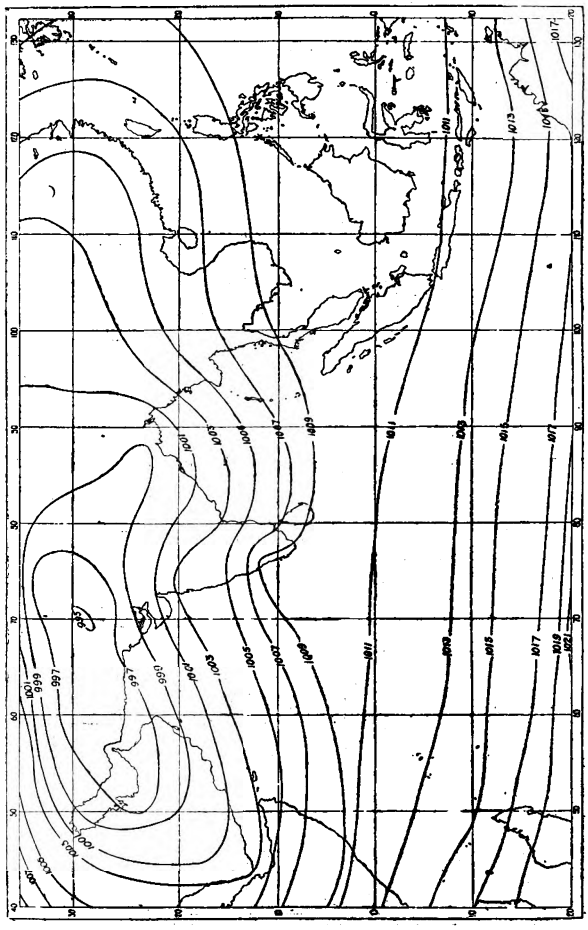

FIG. 109.—Pressure distribution in millibars—July.

the Khasi hills of Assam, and the whole east coast of Burmah. The driest regions are Baluchistan, much of which has less than 125 mm. (5 inches) a year, and the central Deccan with about 500 mm. (20 inches),

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Meteorological Table for Baghdad.

Lat. 33° 21′ N. Long. 44° 26′ E. Height above M.S.L. 120 feet.

Month.	Temperature. Record. Max.	Temperature. Record. Min.	Relative Humidity.‡	Cloud Amount. Scale 0–10.‡	Precipitation. Monthly.	Precipitation. Record in Day.	Days of Precipitation.§	Days of Snow.	Days of Frost.	Days of Fog.	Days of Strong Wind or Gale.	Days of Thunder.	Wind.‡ Prevailing Wind Direction.	Wind.‡ Percentage of Observations from :— N.	E.	S.	W.	Calm.	Upper Wind. (3,000 ft.) Percentage of Observations from :— N.	E.	S.	W.	Calm or Variable.
	°F.	°F.	%		mm.	mm.																	
Jan.	80	21	78	3·2	29	34	5			2·8		1	Calm	19	2	9	16	54	Oct. to Mar.				
Feb.	85	28	73	3·1	28	64	4			0·6		0	Calm	20	5	11	11	53	29	15	21	29	6
Mar.	99	33	69	2·8	31	41	5			0·1		1	Calm	21	8	13	9	49					
Apr.	108	44	60	2·3	21	44	3			0·0		1	Calm	3	5	9	15	48	Apr. to May.				
May	113	47	50	1·7	5	20	1			0·0		2	N.N.W.	29	5	5	15	46	40	16	17	24	3
June	119	63	37	0·3	0	1	0·1			0·0		0	N.N.W.	50	4	2	19	25					
July	123	70	37	0·1	0	0	0			0·0		0	N.W.	44	1	0	32	23	June to Sept.				
Aug.	121	69	40	0·2	1	12	0·1			0·0		0	N.W.	40	3	1	26	31	59	10	4	25	2
Sept.	117	56	42	0·4	0	1	0·1			0·0		0	N.N.W.	35	3	2	18	42					
Oct.	108	47	51	1·5	2	13	1			0·1		0	N.N.W.	28	5	4	9	53					
Nov.	95	29	66	2·2	21	53	3			0·7		0	Calm	22	4	8	10	56	*See* Jan.				
Dec.	81	19	79	2·8	31	37	5			2·0		0	Calm	18		10	10	58					
Year	123	19	57	1·7	169	64	27	About once every few years.		6·3		5	N.N.W.	29	5	5	16	45	42	14	15	26	4
Years	25				29					20		25		24					2				

‡ Mean of observations at :—8 h.

§ 0·2 mm. or more.

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The average rainfall in a rainy day is about 25 mm. (1 in.) so that the number of wet days can be taken as approximately equal to the number of inches of rainfall.

5. The distribution of *Cloudiness* and *Humidity* follows that of rainfall; the cloudiest regions being southern India and Ceylon, north-eastern Bengal and southern Burmah, all with an average annual cloudiness of more than five-tenths; Baluchistan and eastern Punjab have less than two-tenths; except in the Himalayas the cloud amount is very small from November to April, increases in May and June, and exceeds seven-tenths over most of the country (except the north-west) in July and August. In the rainiest regions the relative humidity averages 80 to 90 per cent. in the latter months.

6. No statistics are available as to *mist* but it is probably frequent in the rainy season, and also in winter in the early morning. *Fog* is rare except in the hilly districts. Table 11 shows the amount of rainfall and frequency of rainy days and thunderstorms at certain points in India.

7. *Cyclones and Gales.* The "depressions" of Egypt and Mesopotamia referred to in the preceding sections sometimes penetrate as far as north-west India during the winter months, causing some rain or snow; but the velocity of the wind is not great. Further south, from January to March, steady moderate north-east winds prevail. Squally weather is sometimes experienced in the Persian Gulf and along the Mekran coast. The north-east monsoon occasionally attains the force of a gale during February, but true tropical cyclones are very rare in this season, occurring only once in many years. Such storms have given rise to occasional winds of storm or hurricane force (75 mi/hr.) over the sea. The true cyclone season extends from April to December, and during the 36 years 1877 to 1912 the number recorded was as follows:—

Table 12. Frequency of cyclones in the Bay of Bengal, 1877 to 1912:—

Month.	Apr.	May	Jun.	July	Aug	Sep.	Oct.	Nov	Dec.	Year.
Severe Cyclones -	5	10	7	6	2	7	14	18	8	77
Moderate Cyclones -	1	7	15	29	21	25	22	13	4	137
Feeble Cyclones -	1	4	20	30	32	38	15	6	5	151
Total - - -	7	21	42	65	55	70	51	37	17	365
Per cent. - -	2	6	11	18	15	19	14	10	5	—

This table shows that in September and July there is an average of nearly two storms in each month, and in June, August, October and November an average of more than one, though of course all these storms do not affect the same localities.

Severe cyclones are those in which the wind exceeds force 10 (55 mi/hr.), and in which there is often (but not always) a characteristic calm area at the centre. In moderate cyclones the wind ranges between forces 8 (39 mi/hr.) and 10 (55 mi/hr.). In feeble cyclones the wind does not reach force 8. It should be noted that severe cyclones are most frequent in November, October and May, and moderate cyclones from July to October.

8. A typical cyclone consists of a central calm area of low pressure with a diameter up to 70 miles round which the winds blow in an "anti-clockwise" direction. The velocity is greatest in a limited belt near the centre, and decreases more or less rapidly to the limits of the storm, which may have a total diameter of several hundred miles. At the surface of the ground or sea the winds are directed slightly inwards: but at a height of 1,500 feet or more they are probably concentric. The whole system advances north-westward, at a rate which varies greatly, but is usually

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Table 11.—Rainfall, Raindays and Thunder in India.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
I.—*Rainfall in Millimetres.*													
Calcutta	9	28	37	48	146	302	318	322	251	106	17	5	1589
Bombay	3	8	6	12	138	505	616	367	271	42	11	1	1980
Madras	35	8	5	13	27	48	100	118	127	298	362	148	1289
Mysore	3	3	11	59	137	61	59	79	102	174	51	12	751
Colombo	91	53	112	252	311	192	130	85	126	357	307	140	2156
Singapore	235	170	188	194	168	176	172	199	169	204	253	274	2402
II.—*Raindays.**													
Calcutta	1	2	2	3	7	13	18	18	13	6	1	0·4	85
Bombay	0·1	0·1	0	0·1	1	14	22	19	13	3	0·4	0·1	73
Madras	2	1	0·3	1	1	4	7	8	7	10	11	5	57
Mysore	0·2	0·3	1	4	8	6	7	6	8	6	4	1	52
Colombo	8	5	9	16	20	18	13	12	14	21	17	12	165
Singapore	15	11	13	15	13	14	12	14	13	16	18	19	173
III.—*Days with Thunder.*													
Calcutta	0·4	1	4	5	8	7	7	6	7	2	0	0	47
Bombay	0	0	0·4	0·6	1	6	1	0·7	5	5	1	0	21
Madras	0·1	0	0·5	0·6	2	6	5	6	4	5	1	0·1	30
Mysore	0·1	0·2	1	5	8	2	1	2	3	4	1	0	27
Colombo	1	3	5	8	7	2	2	0·3	1	4	7	2	42
Singapore	0·9	2	4	7	5	5	4	5	6	5	7	5	56

* Day with 2·5 mm. or more rain.

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10–14 miles per hour or 240 to 340 miles per day. The direction of movement varies with the season.

(i) *The Smaller Storms of the Rainy Season* (*June to September*).—In the great majority of these storms strong winds occur only in the south and east quadrants. They nearly always form near the head of the Bay of Bengal and pass westwards across the Orissa coast, through the Central Provinces or along the Ganges valley, sometimes as far as Rajputana or Punjab. Although the wind force often does not exceed 39 mi/hr., they are small and hence give rise to rapid shifts of wind. The chief indication of their formation is the suspension of the ordinary south-west monsoon and the setting in of N.E. or E. winds and of accompanying fine weather in the midst of the rainy season. The south-west monsoon wind is not a steady wind, but goes through a series of pulsations or alternations of advance and withdrawal, and the cyclones form in the intervals of partial retreat. As they advance inland they are accompanied by heavy rain.

(ii) *Storms of the Transition Period* (*April to May, October to December*) are usually very extensive and fierce, and are often generated in the south of the bay between the Andaman Isles and the coast. It may thus happen that the prevailing normal N.E. winds over the north and north-west of the Bay are unaltered in direction, and merely strengthened and steadied by an extensive cyclone in the south of the Bay. In this way a north-east wind, apparently a fair weather wind, may be blowing directly towards a storm. It is therefore most important to ascertain whether, when N.E. winds prevail in the north-west angle of the Bay, they are merely the normal winds of the period or are strengthened by the presence of a cyclone further south. (*See* later under Forecasting.) These storms follow irregular tracks; the more southerly ones frequently strike the coast of Madras, the more northerly ones move northward or north-eastward to Bengal or Upper Burmah. On reaching the coast cyclones generally increase suddenly in intensity, and then die out, either rapidly on meeting a mountain range or more gradually across the plains.

(iii) *Cyclones in the Arabian Sea* are less frequent; they usually move westwards or north-westwards but sometimes strike the coast of Sind.

Upper Air Conditions:

10. Table 13 gives the results of observations with pilot balloons at Agra in the plains and Table 14 similar results at Bangalore in southern India.

Table 13. Winds at Agra, 27° 10′ N., 78° 5′ E.; Height above sea 60 feet:— *Derived from balloon observations 1914–1919.*

Season and months.	Height above ground, feet.	Percentage of observations from									Mean velocity, mi/hr
		N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	
Hot season March to May.	0	6	5	7	10	4	9	27	14	17	5
	6,000	6	1	1	4	5	7	35	40	1	17
	16,000	8	2	0	2	2	13	46	27	0	26
Monsoon period June to Sept.	0	4	6	15	12	6	13	24	9	11	5
	6,000	19	11	14	7	3	4	12	30	0	13
	16,000	11	10	17	13	6	12	14	17	0	13
Cold season Oct. to Feb.	0	4	4	7	5	2	7	34	17	21	3
	6,000	10	3	3	2	4	9	28	41	0	15
	16,000	2	0	0	1	1	15	62	19	0	33

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Table 14. Winds at Bangalore 12° 58′ N., 77° 38′ E. Height above sea, 3,000 feet:— *Derived from balloon observations 1915–1919.*

Season and months.	Height above ground, feet.	Percentage of observations from									Mean velocity, mi/hr
		N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	
Hot season March to May.	0	4	5	18	9	6	18	33	5	1	5
	6,000	13	16	33	14	3	4	6	11	0	12*
	16,000	6	17	29	11	8	8	13	7	1	14†
Monsoon period, June to Sept.	0	2	2	2	1	4	17	60	12	0	9
	6,000	8	5	3	1	3	3	57	20	0	16*
	16,000	8	11	18	11	7	13	24	8	0	12†
Cold season Oct. to Feb.	0	5	19	44	9	3	4	2	3	1	5
	6,000	9	28	38	9	3	3	5	5	0	13*
	16,000	11	21	28	10	7	6	11	6	0	11†

* At 3,600 feet. † At 13,000 feet.

11. At Agra W. or N.W. winds are most frequent at all heights throughout the year, and these winds also have the greatest velocity. From October to May half the winds experienced at 16,000 feet from between S.W. and N.W. exceed 30 mi/hr. The upper winds are most light and irregular during the monsoon period.

12. At Bangalore, further south the upper winds are prevailingly easterly between October and May, during which period they rarely exceed 30 mi/hr. at any height. During the monsoon period, however, westerly winds prevail up to 5,000 feet above the ground, reaching a maximum velocity sometimes exceeding 30 mi/hr. at about 3,000 feet. At greater heights this westerly current falls off and is replaced by a strong easterly current above 15,000 feet. In Fig. 110 this reversal of wind direction with height during the south-west monsoon is shown by means of the north-south and east-west components of the resultant wind.

13. Dust storms and other convection effects are very common in the hot season, causing bumpy and uneven flying. These may extend to a height of 5,000 to 7,000 feet. The height of cyclones varies, but disturbed conditions probably extend to at least 10,000 feet in most cases.

Forecasting:

14. Forecasts can be obtained by telegraph from the Director-General of Observatories, Meteorological Office, Simla. During the cold weather, flying is possible on nearly all days, except perhaps in the far north-west. During the hot weather flying should always be possible in the early morning and in the evening, but during the day the great heat, dust, low visibility and bumpiness interfere to a certain extent. There are also severe local squalls with much thunder and rain, especially in Bengal and Orissa. In the monsoon period the temperature is lower but during the rainy spells the air is disturbed with frequent squalls and thunder. When the south-westerly winds lull, a fine spell of a day or more may be expected, when flying should be good. After the beginning of May it is necessary to take account of cyclones. Adequate warning of these can be had from the Meteorological Office if a telegraph is available.

15. There are also local prognostics of a cyclone, as follows:—

(i) The occurrence of a succession of squalls which increase in frequency and intensity as the storm area approaches. Squally weather in the Bay always precedes a cyclone, but the latter is not necessarily a sequel to it.

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(ii) Barometric indications. The regular semi-diurnal variation of pressure, with maxima about 10 h. and 22 h., and minima about 4 h. and 16 h. has a range of about 3 mb. (one tenth inch). If there is any disturbance of this regular variation, caution should be shown. Eliot's

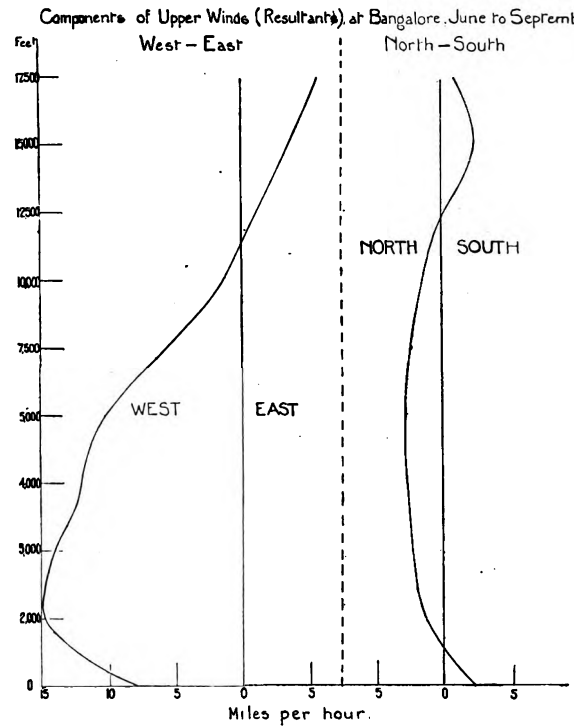

FIG. 110.

rule is: If the barometer reading (corrected for temperature) is at any time during the cyclone season, 3 mb. (0·1 in.) below the normal for the time of day, the chances are 2 to 1 that a cyclone has formed in the Bay; if the decrease below normal is 5 mb. (0·15 in.), the chances are at least 3 to 1, and if 7 mb. (0·2 in.) below, it is practically certain that a cyclonic storm has formed. It must be remembered, however, that the barometer is frequently unusually high and steady on the outskirts of a storm in formation, but the same conditions also frequently occur in fine weather.

A meteorological table for Calcutta is shown on page 258.

48. METEOROLOGICAL NOTES.—THE FAR EAST.

1. Under this heading may be grouped the region extending from Hong Kong, the Philippines and the Straits Settlements to the East Indies and northern Australia. Lying wholly within the tropics on both

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sides of the equator, the climate is warm and moist throughout the year (with the exception of Hong Kong, which has a dry cool winter). In such a large complex region local peculiarities count for a great deal, and only a brief general description can be given here.

Surface Conditions:

2. *Pressure and Winds.*—From November to March, during the winter of the northern hemisphere pressure is high over eastern Asia and falls steadily to a low-pressure area over northern Australia. During this season the winds blow very steadily from the north-east until they approach the equator, where they commence to back so that in the southern hemisphere they blow from north-west. Near the coast of Asia the *North-East Monsoon* has a considerable velocity (*see* Table 15) but further south this diminishes, and the *North-West Monsoon* does not attain any great force. From May to September, on the other hand, pressure is low over eastern Asia and high over Australia, and the wind blows from the opposite directions—south-east in the southern hemisphere and south or south-west north of the equator. April and October are transition months, during which pressure is lowest near the equator to which the wind blows from both sides; these are unsettled months with frequent variable winds and squalls. The southerly monsoon sets in earlier in the south than in the north, and the northerly monsoon sets in earlier in the north than in the south; there are also many local changes of direction due to the presence of high islands, though these would not appreciably affect the winds at a height of 5,000 feet. In some places these local winds give rise to squalls of gale force.

Table 15. Average wind velocity (mi/hr.) about 50 to 80 feet above the ground:—

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug	Sep.	Oct.	Nov	Dec.
Hong Kong	14	15	16	15	13	12	11	9	12	14	13	12
Manila -	4	5	5	6	5	5	7	8	6	4	4	4
Batavia -	2	2	2	2	2	2	2	3	3	3	2	2
Maety Miarang (East of Timor).	16	15	12	13	16	17	16	15	13	11	8	11

The figures for Hong Kong, Manila and Batavia represent the coastal districts and the falling off as the equator is approached. Maety Miarang, however, where the observations are taken at an isolated lighthouse, indicates the velocity over the open sea.

3. *Typhoons* or Baguios are experienced on the coast of China and in the Philippines; they are unknown south of 5° N. and rare south of 10° N., though Sandakan in British North Borneo (6° N.) has been visited once. These storms are similar to the cyclones of the Bay of Bengal, but on the average are probably more severe. Three groups are recognised; the first forms well to the east of the Philippines, and curves northward over Japan, the second starts from north or north-east of the Philippines and moves towards Formosa or Southern China, and the third moves from the neighbourhood of the Philippines due west. The monthly frequency during the 39 years 1880 to 1918 was as follows:—

Table 16. Frequency of Typhoons in the Far East:—

	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug	Sep.	Oct.	Nov	Dec.
Total (39 years)	18	7	11	21	45	59	122	148	108	112	78	28
Average number per month	0·5	0·2	0·3	0·5	1·2	1·5	3·2	3·8	2·8	2·9	2·0	0·7

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Meteorological Table for Calcutta (Alipore Obsy).

Lat. 22° 32′ N. Long. 88° 24′ E. Height above M.S.L. 21 feet.

Month.	Temperature. Record. Max.	Temperature. Record. Min.	Relative Humidity.‡	Cloud Amount. Scale 0–10.‡	Precipitation. Monthly.	Precipitation. Record in Day.	Days of Precipitation.§	Days of Snow.	Days of Frost.	Days of Fog.	Days of Strong Wind or Gale.	Days of Thunder.	Wind.‡ Prevailing Wind Direction.	Wind.‡ Percentage of Observations from :— N.	E.	S.	W.	Calm.	Upper Wind (6,000 ft.). Percentage of Observations from :— N.	E.	S.	W.	Calm or Variable.
	° F.	° F.	%		mm.	mm.																	
Jan.	88	44	85	2·0	9	42	1					0·4	N.W.	36	8	9	22	25	9	0	28	60	3
Feb.	98	46	82	2·6	28	81	2					1	W.M.W.	25	9	20	31	15	9	2	15	67	7
Mar.	103	50	80	2·9	37	70	2					4	S.W.	10	6	44	32	8	3	2	39	54	2
Apr.	107	61	79	3·6	48	107	3					5	S.S.W.	5	7	60	25	3	3	3	53	40	1
May	107	65	79	4·7	146	156	7					8	S.S.W.	4	15	60	18	3	7	10	50	32	1
June	108	70	85	7·4	302	304	13					7	S.S.W.	4	19	56	18	3	3	21	44	25	7
July	98	68	88	8·6	318	184	18					7	S.W.	3	22	51	20	4	3	23	40	22	12
Aug.	94	74	89	8·5	322	227	18					6	S.	5	23	48	18	6	3	29	42	16	10
Sept.	95	72	87	6·9	251	369	13					7	S.W.	6	24	41	19	10	8	33	34	17	8
Oct.	94	63	85	3·6	106	82	6					2	N.W.	24	17	17	21	21	17	34	20	19	10
Nov.	91	51	82	2·0	17	81	1					0	N.N.W.	51	11	3	14	21	41	30	10	17	3
Dec.	85	45	81	1·5	5	28	0·4					0	N.W.	51	6	3	15	25	19	0	14	65	2
Year	108	44	83	4·5	1,589	269	85					47	S.W.	19	14	34	21	12	10	16	32	36	6
Years	43		32		43	28	43					10					27				6		

‡ Mean of observations at 8 h.

§ 3 mm. or more.

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4. *Land and Sea Breezes* are an important consideration on the coasts of the continents and large islands, but are feebly developed on the small islands. When the monsoons are weak, land and sea-breezes predominate; but even when the monsoons are well-developed, their direction changes considerably during the day and night. The change from land to sea-breeze occurs about 10 to 11 h.; that from sea to land-breeze shortly after sunset near mountainous coasts and later near flat country. The force of the sea-breeze decreases gradually from the coast both landwards and sea-wards; it is usually still perceptible 30 miles from the shore. The force is greatest near mountainous country sloping gradually to the sea; it also depends largely on the cloudiness, being greatest on clear days, and on the condition of the soil, being greater for instance when the rice-fields are dry and bare than when they are in cultivation.

5. *The Rainfall* is generally heavy, and some may occur at any time of the year. North of the equator May to August have most rain, while south of the equator November to February are the rainiest months. On high islands the aspect of the coast is of primary importance, since the heaviest rain is likely to fall on a coast which is directly exposed to the prevailing monsoon; thus a north-east coast will have its rainfall during the north-east monsoon and a south-west coast during the south-west monsoon. In general the following classification may be given :—

(*a*) *North of Equator.*

(i) Steep coasts facing north-east. Two rainy seasons, or rainfall throughout year. Heaviest fall generally during north-east monsoon.
(ii) Others coasts and flat islands. Rainy season May to August Dry season November to February.

(*b*) *South of Equator.*

(i) Steep coasts facing south-east. Two rainy seasons or rainfall more or less all the year. Heaviest fall generally during south-east monsoon.
(ii) Other coasts and flat islands. Rainy season November to February. Dry season May to August.

The rainfall is generally heaviest in the middle of the day or afternoon. The frequency of rain days and the distribution of cloudiness and humidity, generally agree with the rainfall (*see* Table 17). In the interior cloudiness generally reaches a maximum in the early afternoon, but at sea and on the coast the maximum occurs in the morning while the afternoon is clear.

6. *Thunder* is most frequent during the rainy season and especially in the transition between the monsoons. Some of the thunderstorms are very heavy and are accompanied by severe squalls. Thunder has a marked diurnal variation; at Batavia it is most frequent between 12 h. and 18 h. and rarest between 6 h. and 12 h.

7. Very little information is available as to *mist or fog*; mist occurs at times in the night and early morning, especially above the marshy lower sections of the great rivers, but is speedily dissipated by the rising sun. Mist and fog are practically unknown at sea.

8. *Haziness* may be developed, especially towards the close of dry seasons. The outlines of the mountains become indistinct and stars of the 4th or 5th magnitude become invisible. In the Gaspar and Karimata Straits this dry haze may thicken to a grey fog, the thickness of which increases with the strength of the south-easter. Near Banka and Billiton the visibility may be less than a mile. This haze is dissipated by the rains. It is limited to the lower 1½ to 2 miles; at the upper limit it usually ends abruptly and above it the air is remarkably transparent. It partly consists of smoke and is most intense in the early morning hours in the lowest air-layers above the sea close to the shore. In spite of this haziness, however, the visibility in the lower air-layers is much better than in Western Europe, as is shown by the following table of observations of different lighthouses.

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Table 18. Visibility of Lights at Geographical Range :—

Locality.	Lighthouse.	Latitude.	Candle Power.	Geographical range, nautical miles.	Visibility at geographical range.
North Sea -	Terschelling	53° N.	15,000,000 to 30,000,000	20	73%
English Channel	C. Gris Nez	51° N.		21	79%
Brittany -	Ushant -	48° N.		21	83%
Mediterranean	Planier -	43° N.		20	90%
Indian Archipelago	Breueh -	6° N.	60,000	30	90% or more.
	Mendanau	3° S.	12,000	21	
	Dapoer -	3° S.	3,000	17	
	Boeroe -	6° S.	900	12	

Upper Air Conditions :

9. Observations with registering balloons have been taken regularly at Batavia for a number of years. These show that from October to April the north-westerly wind which prevails at the surface gives place to a south-westerly current at a height of only 300 feet. This gives place to a south-easterly current, in October and November at only 3,000 feet, but in December to April at 20,000 feet. At very great heights (30,000 feet) the south-east wind changes to east or E.N.E. Between May and September north-east winds prevail at the surface, quickly giving place to winds from south-east at 300 feet which gradually back to east, blowing from slightly north of east above 8,000 feet. The velocities, however, are not great, averaging only 12 mi/hr. up to 30,000 feet. In February between 3,000 and 6,000 feet the wind has a mean velocity of 18 mi/hr. and blows from slightly south of west; again in July to September between 5,000 and 6,000 feet it is 14 mi/hr. from east. In both cases the velocity decreases slightly above 6,000 feet.

10. At Hong Kong the movement of the lower clouds shows that at 3,000 to 5,000 feet the wind blows from east between September and January; from E.S.E. between February and April, and from S.S.E. or South between May and August, the latter being the rainy period. The upper clouds move from slightly south of west between November and June but are very variable between July and October.

The land and sea breezes are shallow being probably only a few hundred feet in thickness, surmounted by a return current in the reverse direction. A manned balloon liberated at Batavia in September was three times carried out to sea by the upper current and in each case brought back to shore by the sea-breeze.

11. *Bumps* due to irregular heating of the ground are of small importance in the early morning hours but increase in force and frequency with the rising sun. They are found up to the level of the cumulus clouds and are strongest just below them. Above the cumulus they are not met with.

Forecasting :

12. Apart from the regular change of seasons, the weather in the Far East differs little from one day to another, and except on the coast of Asia the practice of short-period forecasting has not been developed. According to the district, local meteorological information can be obtained from :—

The Director, Royal Observatory, Hong Kong.
The Director, Philippine Weather Bureau, Manila.
The Director, Royal Magnetic and Meteorological Observatory, Batavia.

Warnings of typhoons can be obtained from the first two of these; if such warnings are not available, the local prognostics are the same as for the cyclones of the Bay of Bengal.

A meteorological table for Batavia is given on page 262.

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Table 17.—Rainfall and Weather in the Far East.

——	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Rainfall in Millimetres													
Hong Kong	37	43	76	140	297	398	319	365	246	125	36	31	2113
Manila	27	11	19	35	105	234	399	361	370	188	130	63	1942
Sandakan (Borneo)	469	244	206	106	152	185	166	205	239	254	373	449	3048
Batavia	318	323	207	136	111	99	70	43	75	116	148	189	1835
Koepang (Timor)	394	372	221	58	37	10	5	2	3	15	93	253	1463
Port Moresby (New Guinea)	204	236	172	81	68	20	29	21	33	21	50	94	1029
Port Darwin	402	327	250	108	18	4	2	3	13	54	124	264	1569
Number of Rain Days.													
Hong Kong	0·2	0·2	0·5	1·5	4	5	6	4	3	1	1	0·2	26
Manila	5	4	4	4	11	15	23	23	22	19	14	12	156
Sandakan	19	13	13	10	12	14	14	15	15	17	19	20	181
Batavia	20	19	16	12	9	8	6	4	6	9	13	16	138
Koepang	17	16	12	5	3	1	0·6	0·3	0·3	1	7	15	79
Port Moresby	15	15	15	8	6	5	3	4	6	4	6	9	96
Port Darwin	20	18	17	8	2	1	0·3	0·3	2	6	11	16	102
Mean Cloudiness (tenths).													
Hong Kong	6·5	7·4	8·4	8·0	7·4	7·6	6·7	6·5	5·9	5·1	5·2	5·2	6·7
Manila	6·2	5·8	5·0	4·6	6·2	7·3	8·2	8·1	8·1	7·3	6·7	6·9	6·7
Sandakan	6·0	4·6	4·0	3·9	3·9	4·4	4·7	4·9	5·3	4·3	5·4	5·3	4·7
Batavia	7·5	7·5	6·7	5·9	5·3	5·1	4·7	4·5	4·9	5·6	6·8	7·3	6·0
Koepang	3·7	3·6	3·3	1·6	2·3	1·7	1·9	1·2	1·1	1·3	2·3	5·3	2·4
Port Darwin	5·3	5·8	5·3	3·0	2·3	1·7	1·0	1·5	2·0	2·7	3·7	5·2	3·3
Number of Days with Thunder.													
Hong Kong	0·2	0·2	2	4	4	5	5	6	3	0·7	0·1	0·1	30
Batavia	12	12	13	13	10	7	5	5	6	11	15	13	122
Port Darwin	13	11	10	4	0·8	0·1	0·1	0·1	1·5	7	14	15	76
Number of Days with Fog.													
Hong Kong	4	5	8	7	2	0·7	0.9	3	3	0·8	0·8	2	36
Port Darwin	0	0	0	0·1	0·2	0·6	1	2	0·6	0·2	0	0	5

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Meteorological Table for Batavia.

Lat. 6° 11′ S. Long. 106° 50′ E. Height above M.S.L. 26·2 feet.

Month.	Temperature. Record. Max.	Temperature. Record. Min.	Relative Humidity.‡	Cloud Amount. Scale 0–10‡.	Precipitation. Monthly.	Precipitation. Record in Day.	Days of Precipitation.§	Days of Snow.	Days of Frost.	Days of Fog.	Days of Strong Wind or Gale.	Days of Thunder.	Wind.‡ Prevailing wind Direction.	Wind.‡ Percentage of observations from :— N.	E.	S.	W	Calm.	Upper Wind. Direction of Winds at Heights of :— 1,000′	2,000′	5,000′	8,000′	12,000′
	°F.	°F.	%		mm.	mm.																	
Jan.	92	69	87	7·5	318	286	20				…	12	N.N.W.	25	2	4	30	39	W.S.W.	W.	W.	W.	W.
Feb.	91	69	87	7·5	323	180	19				…	12	N.W.	26	2	4	28	40					
Mar.	92	69	86	6·7	207	147	16				…	13	Calm	23	8	7	24	38	S.S.W.	S.W.	W.	W.	W.
Apr.	92	70	85	5·9	136	192	12				…	13	N.E.	20	19	9	13	39					
May	92	70	84	5·3	111	95	9				…	10	N.E.	20	25	8	8	39	S.S.E.	E.	E.	E.	E.
June	91	67	83	5·1	99	135	8				…	7	E.N.E.	17	27	9	8	39					
July	90	67	81	4·7	70	115	6				…	5	N.E.	22	30	7	6	35					
Aug.	92	67	78	4·5	43	84	4				…	5	N.E.	26	29	8	5	32	E.S.E.	E.	E.	E.	E.
Sept.	96	66	78	4·9	75	117	6				…	6	N.N.E.	31	22	8	6	33					
Oct.	95	69	79	5·6	116	83	9				…	11	N.N.E.	29	18	10	9	34	S.W.	S.W.	S.	S.	S.E.
Nov.	96	68	82	6·8	148	127	13				…	15	Calm	24	12	12	18	34					
Dec.	92	67	85	7·3	189	159	16				…	13	W.	21	4	7	30	38		*Se*	*e* Jan.		
Year	96	66	83	6·0	1,835	286	138				…	122	Calm	24	16	8	15	37					
Years	53		53	37	42						16	34	25	22									

‡ Mean of observations hourly.

§ 0·5 mm. or more.

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Specification of the Beaufort Scale with the corresponding scale of Wind-speed at 33 ft. above ground† in the open.

Beaufort Number.	General Description of Wind.	Specification of Beaufort Scale. For Coast Use, based on Observations made at Scilly, Yarmouth, and Holyhead.	Specification of Beaufort Scale. For use on Land, based on Observations made at Land Stations.	Limits of Speed. Statute Miles per Hour.	Limits of Speed. Metres per Second.	Beaufort Number.
0	Calm	Calm	Calm; smoke rises vertically	Less than 1	Less than 0·3	0
1	Light air	Fishing smack* just has steerage way.	Direction of wind shown by smoke drift, but not by wind vanes.	1–3	0·3–1·5	1
2	Slight breeze	Wind fills the sails of smacks, which then move at about 1–2 miles per hour.	Wind felt on face; leaves rustle; ordinary vane moved by wind.	4–7	1·6–3·3	2
3	Gentle breeze	Smacks begin to careen, and travel about 3–4 miles per hour.	Leaves and small twigs in constant motion; wind extends light flag.	8–12	3·4–5·4	3
4	Moderate breeze	Good working breeze; smacks carry all canvas, with good list.	Raises dust and loose paper; small branches are moved.	13–18	5·5–7·9	4
5	Fresh breeze	Smacks shorten sail	Small trees in leaf begin to sway; crested wavelets form on inland waters.	19–24	8·0–10·7	5
6	Strong breeze	Smacks have double reef in main sail. Care required when fishing.	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty.	25–31	10·8–13·8	6
7	High wind	Smacks remain in harbour, and those at sea lie to.	Whole trees in motion; inconvenience felt when walking against wind.	32–38	13·9–17·1	7
8	Gale	All smacks make for harbour, if near.	Breaks twigs off trees; generally impedes progress.	39–46	17·2–20·7	8
9	Strong gale	—	Slight structural damage occurs (chimney pots and slates removed).	47–54	20·8–24·4	9
10	Whole gale	—	Seldom experienced inland; trees uprooted; considerable structural damage occurs.	55–63	24·5–28·4	10
11	Storm	—	Very rarely experienced; accompanied by widespread damage.	64–75	28·5–33·5	11
12	Hurricane	—	—	Above 75	33·6 or above.	12

* The fishing smack in this column may be taken as representing a trawler of average type and trim.
† Wind speed should not be estimated from an anemometer on the ridge of a building.

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CHAPTER X.

MISCELLANEOUS TABLES AND INFORMATION.

49. IMPERIAL WEIGHTS AND MEASURES.

WEIGHTS.

Avoirdupois.

(Used in almost all commercial transactions and ordinary dealings.)

Drams.	Ozs.	Lbs.	Qrs.	Cwts.	Ton.
1	0·0625	0·0039063	0·0001395	0·0000349	0·00000174
16	1	0·0625	0·0022321	0·000558	0·00002790
256	16	1	0·0357143	0·0089285	0·00044643
7168	448	28	1	0·25	0·0125
28673	1792	112	4	1	0·05
573440	35840	2240	80	20	1

Troy.

(Used for rare metals.)

Grains.	Dwt.	Ozs.	Lb.
1	0·0416667	0·0020833	0·0001737
24	1	0·05	0·0041666
480	20	1	0·0833333
5760	240	12	1

Apothecaries' Weight.

Grains.	Scruples.	Drms.	Oz.
1			
20	1		
60	3	1	
480	24	8	1

Apothecaries' Fluid Measure.

(Used for Medicine.)

Minims (Drops).	Drms.	Ozs.	Pints.
1			
60	1		
480	8	1	
9600	160	20	1

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Particular Weights.

A firkin of butter	= 56 lbs.
,, of soft soap	= 64 ,,
A barrel of raisins	= 112 ,,
,, (or pack) of soft soap	= 256 ,,
A sack of potatoes = 168 lbs.; coals = 224 lbs.; flour	= 280 ,,
A muld of whole mealies	= 196 ,,
,, crushed mealies	= 200 ,,
Bag of Coffee	= 1¼ to 1½ cwt.
,, Rice (East India)	= about 1½ cwt.
Bale of coffee (Mocha)	= 2 to 2½ cwt.
Barrel of beef	= 200 lbs.
,, butter	= 224 ,,
,, gunpowder	= 100 ,,
,, tar	= 26¼ gallons.
Bushel of coal	= 80 lbs.
Cask of rice (American)	= 6 cwts.
Chaldron of coke	= 36 bushels.
Chest of tea	= about 84 lbs.
Gross	= 12 doz.
Hogshead of sugar	= 13 to 16 cwts.
Loaf quartern	= 4 lbs.
Tierce of coffee	= 5 to 7 cwts.
,, sugar	= 7 to 9 ,,
Tub of butter	= 84 lbs.
*Truss of straw	= 36 ,,
,, hay	= 56 ,,
,, new hay	= 60 ,,

* Load, 36 trusses = straw, 11 cwts., 2 qrs., 8 lbs.; old hay, 18 cwts.; new hay, 19 cwts., 1 qr., 4 lbs.

Measures.

Length (Linear).

Ins.	Feet.	Yards.	Fathoms.	Furlongs.	Miles.	Knots.
1	0·0833	0·0277	0·00139	0·000126	0·000016	0·000140
12	1	0·3333	0·1667	0·001515	0·000189	0·000164
36	3	1	0·5000	0·004545	0·000568	0·000439
72	6	2	1	0·009091	0·001360	0·00098
7920	660	220	110	1	0·125000	0·1085
—	—	1760	880	8	—	—
—	6079·8	2026·6	1013·3	9·212	1·1515	1

Particular Measures.

A cable's length—1/10 nautical mile: 202·7 yards.
A league—3 miles.
A nautical mile or *geographical mile*—2,026⅔ yards.

Surface (Square).

Inches.	Feet.	Yards.	Rods or Poles.	Roods.	Acre.
1	0·0069444	0·0007716	0·0000255	0·00000064	0·00000016
144	1	0·1111111	0·0036731	0·0000918	0·000023
1296	9	1	0·0330579	0·0008264	0·0002066
39,204	272¼	30¼	1	0·025	0·00625
1,568,160	10890	1210	40	1	0·25
6,272,640	43560	4840	160	4	1

A square mile contains 640 acres—2,560 roods—6,400 chains—102 400 rods, poles, or perches—3,097,600 square yards.

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N.B.—The term "square feet" must not be confounded with "feet square." A piece of cloth said to measure 6 square feet consists of 6 squares of a foot each, but a piece said to measure 6 feet square would be 6 feet along each side, and comprise 36 squares of a foot each.

Capacity (Cubic).

Cubic Inches.	Cubic Feet.	Cubic Yards.
1	0·0005788	0·00000214
1,728	1	0·0370370
46,656	27	1

Liquid Measure.

Gills.	Pts.	Qts.	Galls.	Firkins.	Kilderkins.	Barrels.
1	—	—	—	—	—	—
4	1	—	—	—	—	—
8	2	1	—	—	—	—
32	8	4	1	—	—	—
378	72	36	9	1	—	—
756	144	72	18	2	1	—
1,512	288	144	36	4	2	1

Dry Measure.

Gills.	Pts.	Qts.	Galls.	Pecks.	Bushels.	Qrs.
1	—	—	—	—	—	—
4	1	—	—	—	—	—
8	2	1	—	—	—	—
32	8	4	1	—	—	—
64	16	8	2	1	—	—
256	64	32	8	4	1	—
2,048	512	256	64	32	8 (2 sacks)	1

One chaldron contains 36 bushels.

Equivalents of Imperial and Metric Weights and Measures.

Linear Measure.

Imperial.

1 inch = 25·4 millimetres.
1 foot = 0·3048 metre
1 yard = 0·914399 metre.
1 mile = 1·6093 kiloms.

Metric.

1 millimetre = 0·03937 in (mm.).
1 centimetre = 0·3937 in (1/100 m).
1 decimetre = 3·937 ins. (1/10 m.).
1 metre (m.) = 39·370113 ins. / 3·280843 ft. / 1·0936143 yds.
1 kilometre (1,000 m.) = 0·62137 mile.

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Square Measure.

1 sq. in. = 6·4516 sq. centimetres.
1 sq. centimetre = 0·15500 sq. in.
1 sq. metre = 10·7639 sq. ft.
1 sq. yd. = 0·836126 sq. metre.
1·1960 sq. yds.

Cubic Measure.

1 cub. in. = 16·387 cub. centimetre.
1 cub. centimetre = 0·0610 cub. in.
1 cub. ft. = 0·028317 cub. metre.
1 cub. decimetre (c.d.) = 61·024 cub. in.
1 cub. yd. = 0·764553 cub. metre.
1 cub. metre = { 35·3148 cub. ft. / 1·307954 cub. yds.

Measure of Capacity.

1 pint = 0·568 litre.
1 litre = 1·75980 pints.
1 gallon = 4·5459631 litres.

Weight.

1 lb. (7,000 grains) = 0·45359243 kilogram.
1 kilogram (1,000 grm.) = 2·2046223 lb.
1 ton = 1,016 kilograms.

Comparative Table.

Inches and Millimetres.

Fraction Inches.	Decimal Inches.	Millimetres.	Fraction Inches.	Decimal Inches.	Millimetres.
—	·001	·025	$\frac{5}{32}$	·1562	3·969
—	·002	·050	—	·1575	4·00
—	·003	·076	$\frac{11}{64}$	·1719	4·365
—	·0039	·100	$\frac{3}{16}$	·1875	4·762
—	·004	·101	—	·1968	5·00
—	·005	·127	—	·2000	5·080
—	·006	·152	$\frac{13}{64}$	·2031	5·159
—	·007	·177	$\frac{7}{32}$	·2187	5·556
$\frac{1}{128}$	·0079	·200	$\frac{15}{64}$	·2344	5·953
—	·008	·203	—	·2363	6·00
—	·009	·228	$\frac{1}{4}$	·2500	6·350
—	·010	·254	$\frac{17}{64}$	·2656	6·745
—	·0118	·300	—	·2756	7·00
$\frac{1}{164}$	·0156	·3968	$\frac{9}{32}$	·2812	7·144
—	·0157	·400	$\frac{19}{64}$	·2968	7·540
—	·0197	·500	—	·3000	7·620
—	·0236	·600	$\frac{5}{16}$	·3125	7·937
—	·0276	·700	—	·3150	8·00
$\frac{1}{32}$	·0312	·794	$\frac{21}{64}$	·3284	8·334
—	·0315	·800	$\frac{11}{32}$	·3437	8·731
—	·0354	·900	—	·3500	8·890
—	·0394	1·00	—	·3543	9·00
$\frac{3}{64}$	·0469	1·191	$\frac{23}{64}$	·3594	9·128
—	·0500	1·270	$\frac{3}{8}$	·3750	9·525
$\frac{1}{16}$	·0625	1·587	$\frac{25}{64}$	·3906	9·921
$\frac{5}{64}$	·0781	1·984	—	·3937	10·00
—	·0787	2·00	—	·4000	10·160
$\frac{3}{32}$	·0937	2·381	$\frac{13}{32}$	·4062	10·319
—	·1000	2·540	$\frac{27}{64}$	·4219	10·716
$\frac{7}{64}$	·1094	2·778	—	·4331	11·00
—	·1181	3·00	$\frac{7}{16}$	·4375	11·112
$\frac{1}{8}$	·1250	3·175	—	·4500	11·430
$\frac{9}{64}$	·1406	3·572	$\frac{29}{64}$	·4531	11·509
—	·1500	3·810	$\frac{15}{32}$	·4687	11·906

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COMPARATIVE TABLE—*continued.*

Inches and Millimetres—*continued.*

Fraction Inches.	Decimal Inches.	Millimetres.	Fraction Inches.	Decimal Inches.	millimetres.
—	·4724	12·00	—	·7480	19·00
31/64	·4844	12·303	3/4	·7500	19·050
1/2	·5000	12·700	49/64	·7656	19·446
—	·5118	13·00	25/32	·7812	19·843
33/64	·5156	13·096	—	·7874	20·000
17/32	·5312	13·493	51/64	·7969	20·240
35/64	·5469	13·890	—	·8000	20·320
—	·5500	13·970	13/16	·8125	20·637
—	·5512	14·00	—	·8268	21·00
9/16	·5625	14·287	53/64	·8281	21·034
37/64	·5781	14·684	27/32	·8437	21·431
—	·5906	15·00	—	·8500	21·590
19/32	·5937	15·081	55/64	·8594	21·827
—	·6000	15·240	—	·8661	22·00
39/64	·6094	15·478	7/8	·8750	22·225
5/8	·6250	15·875	57/64	·8906	22·621
—	·6299	16·00	—	·9000	22·859
41/64	·6406	16·271	—	·9055	23·00
—	·6500	16·510	29/32	·9062	23·018
21/32	·0562	16·668	59/64	·9219	23·415
—	·6693	17·00	15/16	·9375	23·812
43/64	·6719	17·065	—	·9449	34·00
11/16	·6875	17·462	—	·9500	24·129
—	·7000	17·780	61/64	·9531	24·209
45/64	·7031	17·859	31/32	·9687	24·606
—	·7087	18·00	63/64	·9842	25·000
23/32	·7187	18·256	1	1·0000	25·400
47/64	·7344	18·652			

COMPARATIVE TABLE.

Miles, Kilometres and Knots.

Miles.	Kilo-metres.	Knots.	Miles.	Kilo-metres.	Knots.
·621	1·	·539	5·757	9·265	5·
1·	1·609	·8684	6·	9·645	5·210
1·1515	1·853	1·	6·215	10·	5·390
1·246	2·	1·078	6·909	11·118	6·
1.864	3·	1·617	7·	11·265	6·078
2·	3·219	1·736	8·	12·874	6·947
2·253	3·706	2·	8·060	13·172	7·
2·486	4·	2·156	9·	14·484	7·815
3·	4·828	2·605	9·212	14·824	8·
3·107	5·	2·695	9·322	15·	8·085
3·454	5·559	3·	10·	16·09	8·684
3·729	6·	3·234	10·363	16·878	9·
4·	6·437	3·473	11·515	18·531	10·
4·350	7·	3·773	12·43	20·	10·78
4·606	7·412	4·	15·	24·140	13·02
4·972	8·	4·312	15·537	25·	13·475
5·	8·047	4·342	17·272	27·797	15·
5·593	9·	4·851	18·645	30·	16·17

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COMPARATIVE TABLE.

Miles, Kilometres and Knots.

Miles.	Kilo-metres.	Knots.	Miles.	Kilo-metres.	Knots.
20·	32·18	17·368	57·575	92·656	50·
21·752	35·	18·865	60·	96·55	52·104
23·030	37·062	20·	62·150	100·	53·9
24·86	40·	21·56	69·090	111·187	60
25·	40·233	21·71	70·	112·65	60·788
27·967	45·	24·256	77·685	125·	67·375
28·77	46·329	25·	80·	128·74	69·472
30·	48·27	26·052	80·605	129·718	70·
31·075	50·	26·95	90·	144·38	78·156
34·545	55·594	30·	92·120	148·249	80·
35·	56·31	30·39	93·225	150·	80·85
37·290	60·	32·34	100·	160·92	86·84
40·	64·37	34·736	103·635	166·781	90·
40·302	64·859	35·	108·762	175·	94·325
43·505	70·	37·73	110·	177·02	95·524
45·	72·415	39·07	115·15	185·312	100·
46·062	74·125	40·	124·301	200·	107·8
49·720	80·	43·12	125·	201·16	108·55
50·	80·464	43·420	139·8	225·	121·27
52·8	83·390	45·	143·9	231·6	125·
55·935	90·	48·51	150·	241·35	30·26

COMPARATIVE TABLE.

Altitude.

Metres.	Feet.	Metres.	Feet.
1	3·280	3,000	9,842·4
2	6·561	3,500	11,482·8
5	16·404	4,000	13,123·2
10	32·809	4,500	14,763·2
50	164·04	5,000	16,404·0
100	328·09	5,500	18,044·4
250	820·14	6,000	19,684·8
500	1,640·4	6,500	21,325·2
1,000	3,280·8	7,000	22,965·6
1,500	4,921·2	7,500	24,606·0
2,000	6,561·0	8,000	26,246·4
2,500	8,201·4		

50. MONEYS, WEIGHTS AND MEASURES, OF BRITISH DOMINIONS, COLONIES AND PROTECTORATES.

Note.—British Coinage, Weights and Measures are in use except where otherwise shewn.

Moneys.	Weights and Measures.
British Honduras.	
100 centavos=1 dollar (gold)= 4/1½d. Silver coins: 25 and 50 cents. Bronze coin: 1 cent. British and U.S. gold coins also current.	British or Metric.

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Moneys.	Weights and Measures.
British North Borneo.	
Mexican dollar=1/9d. Nickel coins: 1, 2½ and 5 cents. Bronze coins: 1 and ½ cent.	British or Metric.
Canada.	
100 cents=1 dollar=about 4/1½d. Silver coins: 5, 10, 25 and 50 cents, and 1 dollar. U.S. gold coins also legal.	Imperial yard. 1 lb. av., gallon and bushel. Cwt.=100 lbs. Ton =2,000 lbs.
Cyprus.	
Piastre=40 paras=1½d. Gold coins: British. Silver coins: 18, 9, 4½, and 3 piastres. Bronze coins: 1, ½, and ¼ piastre.	*Length*: 12 ins.=1 ft.=1 pic; 1½ pic=1 yd.; 33 pics=1 chain; 2,640 pics=1 mile. *Weight*: 400 drams=1 oke; 1½ okes =1 Cyprus litre; 44 okes=1 cantar; 180 okes=1 Aleppo cantar; 800 okes=1 ton. *Capacity*: 2 pints=1 quart; 2½ quarts=1 Cyprus litre; 4 quarts= 1 gallon; 8 gallons=1 kile. (Liquid)=9 quarts=1 kouza; 16 kouzas=1 load.
Egypt.	
100 piastres, or 1,000 milliemes= £E (gold)=-1 0s. 6½d. 1 piastre =2½d. about. Gold piece of 20 francs=77 piastres. Indian rupee=6½ piastres. Silver coins: 20, 10, 5, 2 and 1 piastre.	Kassabah=3·88 yds.; Feddan (land) =1·038 acres. Pic=6·05 sq. ft. Rotl=·99049 lb. Oke=2·7513 lbs. Cantar=100 rotls or Heml=200 okes=4·9132 cwts. Ardeb=5·44 bushels. Kela= 3·6316 imperial gallon.
Falkland Islands.	
British.	British.
Fiji.	
British.	British.
Friendly Islands.	
British.	British.
Hong Kong.	
Same as China.	English weights and measures in general use. Tael=1⅓ oz. av.; Catty=1⅓ lb. av.; Picul=133⅓ lb. av.; Chek=14⅝ ins.; Cheung= 12½ ft.
India.	
3 pie=1 pice; 4 pice=1 anna; 16 annas=1 rupee=1/4d.	Length: Ungul=·75 in.; Guz=1 yd.; Koss=2,000 yds. *Weight*: Chittak=2 ozs. av.; Seer= (16 Chittak)=2·204 lbs. av.; Maund=(Bengal) 82·287 lbs. av.; (Madras) approx. 25 lbs.; (Bombay) approx. 28 lbs. *Capacity*: Seer=1·760 pints.

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Moneys.	Weights and Measures.
	Malta.
British.	*Length*: 12 pollice=1 palmo=10$\frac{1}{16}$ ins.; 8 palmo=1 canna=6 ft. 10$\frac{1}{2}$ ins. *Weight*: Rotolo=1 lb. 12 ozs.; 5 Rotoli=1 pesa=8 lbs. 12 oz.; 20 pesa=1 cantaro=175 lbs. *Capacity*: Pint=·8331 pint; Salma =7·9372 bushels. Metric system also in use.
	Mauritius and Seychelles.
Indian rupee=fixed rating 1/4d. Silver coins: 20 and 10 cents. Bronze coins: 5, 2, and 1 cents.	Metric System.
	Newfoundland.
Dollar on gold basis=4/2d. Silver coins: 50, 20, 10 and 5 cents. Bronze coins: cents.	British.
	Nigeria (Southern).
West African Silver coins corresponding to British 2s., 1s., 6d. and 3d. Nickel coins: 1d. and $\frac{1}{10}$d.	British.
	Sierra Leone.
British currency and West African silver coins=2s., 1s., 6d. and 3d. Also 5 franc piece=3s. 10$\frac{1}{2}$d.	British.
	Straits Settlements (Malay States and Labuan.)
Dollar (gold)=2s. 4d. Silver coins: 50, 20, 10 and 5 cent pieces. Copper coins: 1, $\frac{1}{2}$ and $\frac{1}{4}$ cent.	Same as English. Native measures: 16 Tahil=1 Chinese Kati=1$\frac{1}{3}$ lb. av.; 100 Kati=1 Picul=133$\frac{1}{3}$ lbs.; 100 Malay Kati=1 Picul of 142·6 lbs.; 40 Picul=1 Koyan=5,333$\frac{1}{3}$ lbs. av.; Gantang=1 gallon: Chupak=1 quart.
	West Indies, Guiana, etc. (British).
Dollar=100 cents=4s. 1d. about. British coinage principally in use.	British weights and measures generally in use.
	Zanzibar.
Currency=Indian Rupee=1s. 4d. Currency Notes of 5 to 500 rupees in circulation. British sovereign legal tender.	British.

51. FOREIGN MONEYS, WEIGHTS AND MEASURES.

Note.—Currencies since the European War have in many cases become dislocated and subject to fluctuation. Values given were normal prior to the war.

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Moneys.	Weights and Measures.

Abyssinia.

Talari or silver dollar of 16 Menelik piastres = abt. 2s.; Maria Theresa dollar = abt. same value; Silver Coins, ½, ¼ and ⅛ talari. Copper, $\frac{1}{100}$.

Length: Sinzer = 9 ins. Kend = 20ins.
Weight: Ounce = 430 grains; lb. = 12 ozs. (Ivory): 18 ozs. (Coffee); Ferasla = 37½ lbs. av. or 50 lbs. Abyssinian Ivory; 4 Feraslas = 1½ Kantars; 1 Waggia (Ivory) = 480 dol.; 1 Waggia (Rubber) 640 dol. approx.; 60 Feraslas = 1 metric ton.
Capacity: Kunna = abt. ½ bushels (varies); Daula = 2½ bushels.

Algeria.

Same as France.

Same as France.

Argentine Republic.

Gold Coin, 5 dollars. £1 = 5·04 gold dollars. Silver coins, 1 dollar and 50, 20 and 10 centavos. Bronze coins, 2 and 1 centavos. Nickel coins, 20, 10 and 5 centavos. Silver dollar or peso = 4s. 1d. Money in circulation chiefly paper = 1s. 9d. about.

Metric.

Austria Hungary.

Gold coins: 100 krone = £4 3s. 4d.; 20 krone = 16s. 8d; 10 krone = 8s. 4d. Single ducat = 11 crowns 29 heller = 9s. 4¾d. Silver coin: 1 krone = 100 heller = half gulden old coinage = 10d. Exchange abt. 24 krone to £ normally. Silver gulden or florins = 100 kreutzer continue to be legal tender. Nickel coins: 200 heller = 10 kreutzer of old coinage = 2d. 10 heller = 5 kreutzer = 1d. Bronze coins: 2 heller = 1 kreutzer = 1s. 5d. 1 heller = ½ kreutzer = 1s. 10d.

Metric.

Belgium.

Same as France.

Same as France.

Bolivia.

100 centavos = 1 boliviano (paper) = 1s. 7d. Silver coins: 50 and 20 centavos. Nickel coins: 10 and 5 centavos. English and Peruvian gold coins have legal currency.

Metric System legal; old Spanish measures also employed:—
Length: Vara = 3 pies = 36 pulgadas = 33·43 ins.
Vara cuadrada = 0·859 sq. yds.
Weight: Libra = 16 onzas = 1·014 lb. av.
Quintal = 100 libras = 101·44 lb. av.
Arroba = 25 libras = 25·36 lb. av.
Capacity: Arroba (of wine or spirits) = 6·70 Imp. galls.
Galon = 0·74 Imp. galls.

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Moneys.	Weights and Measures.
Brazil.	
Currency, paper, worth about 1s. per milreis (1,000 reis). Silver coins: 2, 1 and ½ milreis. Also bronze and nickel coins.	Metric System.
Bulgaria.	
Lev = 100 stotinki = 9½d. Gold coins: 10 and 20 leva. Foreign: 10 and 20 franc pieces principally in circulation. Silver coins: ½, 1, 2 and 5 leva. Nickel coins: 10 and 20 stotinki. Bronze coins: 2½ and 5 stotinki.	Metric System.
Chile.	
Currency, paper, dollar or peso = 10d. abt. Monetary unit = gold peso = 1s. 6d. £ has legal value of 13⅓ pesos gold.	Metric System in general use.
China.	
1,200 (abt.) cash = tael. Various foreign dollars current, such as Mexican, Japanese Trade and Hong Kong dollars.	*Length*: 10 Fen = 1 Ts'un (inch); 10 Ts'un = 1 Chi'h (foot) = 14·1 English ins. by treaty; 10 Chi'h = 1 Chang = 11 ft. 9 ins. (141 ins. by treaty); 1 Li = ⅓ English mile (abt.) The mow (unit of measurement) is almost ⅙ of an acre. *Weight*: 10 Ch'ien = 1 Liang (Tael) = 1·333 ozs. av.; 16 Liang = 1 Kin (Catty) = 1·333 lbs. av.; 100 Chin = 1 Tan (Picul) = 133·333 lbs. av. *Capacity*: 10 Ko = 1 Sheng (pint) = 1·031 litre; 10 Sheng = 1 Tou (peck) = 10·31 litre.
Colombia.	
100 centavos = 1 peso or dollar, gold = nom. value 4s. Gold coins: 1, 2½ and 5 dollars. Silver coins: real, peseta, half-dollar and dollar. Currency chiefly paper, subject to fluctuation. Paper peso = 1 centavo gold, or $500 = £1.	Metric System. French litre legal standard for liquid measure. *Length*: Vara = 80 centimetres = abt. 31 inches. *Weight*: Kilogramme (Custom House Standard) = 2·204 lbs. av; Arroba = 12½ Kilos, or 25 Colombian lbs.; Quintal = 50 Kilos, or 100 Colombian lbs.; Carga = 125 Kilos or 250 Colombian lbs.; Libra = 1·102 lbs. av.
Corea.	
Japanese gold yen = 2s. 0½d. Notes of Bank of Corea legal tender.	Japanese measures.
Costa Rica.	
100 centimos = 1 colon (gold) = 1s. 11d. abt. Silver coins: 5, 10, 25 and 50 centimos. Silver legal tender to 10 colones; copper to 1 colon. Foreign gold legal. 10.45 colones = £1. 2.15 colones = 1 U.S. gold dollar.	Metric System.

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Moneys.	Weights and Measures.
Crete.	
Same as Greece.	Metric system in general use.
Cuba.	
Monetary unit: Gold peso. Gold coins: 20, 10, 5, 4, 2 and 1 peso. Silver coins: 1 peso, 40 20 and 10 cents. Nickel coins: 5, 2, and 1 cents. Cuban and U.S. coins and currency only legal tender. Silver dollar=abt. 3s. 4d.	Metric System.
Denmark.	
100 ore=1 krone=1s. 1¼d. Gold coins: 20 kroners and 10 kroners; Silver coins: 2 kroner (rigsdaler), 1 krone and 25 ore. 18·159 kroner =£1 sterling.	Metric System.
Ecuador.	
100 centavos=1 sucré, dollar or peso =2s. Gold condor of 10 sucrés= £1.	Metric system legal, but old measures used in commerce. (as under Bolivia).
Finland.	
Finnish mark=100 penni. 25 m. 20 penni=£1 (normal). Gold coins: 10 and 20 marks. Silver coins: 25 and 50 penni, 1 and 2 marks. Copper coins: 1, 5 and 10 penni.	Metric System.
France.	
Franc of 100 centimes=9¼d. 20 franc piece=14s. 7d. Gold coins: 5, 10, 20, 50 and 100 francs. Silver coins: 20 centimes, ½, 1, 2 and 5 franc pieces. Nickel coin: 25 centimes. Bronze coins: 1, 2, 5 and 10 centimes.	Metric System:— *Length*: Millimetre=·039 ins.; Centimetre=10 millimetres=·394 ins; Decimetre=10 centimetres=3.937 ins.; Metre=10 decimetres=39·37 ins.; Kilometre=1,000 metres= 39370·79 ins. (1 Kilometre is approximately ⅝ mile.) *Square*: Centiare=1·196 sq. yds.; Are (100 sq. metres)=119·603 sq. yds.; Hectare=2·471 acres; Kilometre Carré=·386 sq. mile. Metre Cube (Stère)=35·314 cubic ft. *Weight*: Milligramme=0·015 grain troy; Gramme=15·43 grains troy; Kilogramme = 2,205 lbs. av.; Quintal Metrique=100 kilos= 220½ lbs. av.; Tonneau=1,000 kilos=2,205 lbs. *Capacity*: Litre (Liquid)=1·76 pint; Hectolitre (Liquid)=22 gallons; Hectolitre (Dry)=2·75 bushels.
German Empire.	
100 pfennig=1 mark=1s. abt. Thaler=3 marks=2s. 11d. Gold coins: doppel-krone=20 marks; krone=10 marks; halb-krone=5 marks. Silver coins: 1, 2 and 5 marks and 50 pfennig. Nickel coins: 10 and 5 pfennig. Bronze coins: 1 and 2 pfennig.	Metric System

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Moneys.	Weights and Measures.
Greece.	
100 lepta=1 drachma paper=9½d. 25 drachmae 22·5 lepta=£1. Currency, paper, 5, 10, 25, 100, 500 and 1,000 drachmae notes. Silver: 1, 2 and 5 drachmae. Copper and Nickel: 1, 2, 5 and 10 leptas.	Metric System.
Guatemala.	
100 centavos=1 peso or dollar silver =1s. 8d. abt. Currency, paper, peso=abt. 1d.	Metric System.
Hayti.	
Principal currency, paper, dollar= 6½d. (fluctuates considerably). Rate of exchange=5 Haytian gourds=1 U.S. gold dollar.	Metric and British systems used commercially. 1 aune (dry goods)=44 ins. or 1·12 metres. 1 quintal=100 lbs. 1 ton =2,000 lbs.
Holland.	
100 cents=1 guilder or florin=1s. 8d 12 guilders 10 cents=£ sterling. Gold coins=10 florins (16s. 8d.). Silver coins: 2½ guilders, 1 guilder, ½ guilder, and 25 cents.	Metric System.
Honduras Republic.	
100 centavos=1 dollar or peso= gold abt. 4s.; silver abt. 1s. 10d.	Metric System. Old measures still used:—Arroba=25 lbs.; Wine, 3¼ Imp. Galls.; Oil, 2¾ Imp. Galls. Vara=32 ins. Sq. Vara=7$\frac{9}{16}$ sq. ft. Manzana=1⅝ acre. Fanega=1½ Imp. Bushel. Quintal=100 lbs. Tonelada=2,000 lbs.
Iceland.	
Same as Denmark.	Same as Denmark.
Italy.	
100 centesimi=1 lira=9½d. Exchange 25 lira 20 cents=£1. Gold coins: 20 and 10 lira. Silver coins: 5, 2 and 1 lira, and 50 centesimi.	Metric System.
Japan.	
Unit of account=gold yen. 10 rin= 1 sen=½d. 100 sen=1 yen or dollar=2s. 0½d. Gold coins: 5, 10 and 20 yen. Silver coins: 10, 20 and 50 sen. Nickel coin: 5 sen. Bronze coins: 1 sen and 5 rin.	*Length*: Shaku=·994 ft. (3·3 shaku =1 metre); Kujira shaku=1·242 ft.; Sün=1·193 ins.; Ken=6 shaku=5·965 ft.; Jo=10 shaku= 9·942 ft.; Chô=60 ken=357·916 ft.; Ri=36 Chô=2·44 miles; Ri (marine)=1·15 mile; Ri (square) =5·9552 sq. miles; Chô=10 tan= 2·45 acres. *Weight*: Mommé=2·11 drams; or 2·41 dwts. or 120 mommé=1 lb. Kin (catty)=160 mommé=1·322 lb.; or 1·60 lb. Troy. Picul (100 kin)=132·27 lbs.; Kwan=1,000 mommé=8·261 lbs. av., or 10·04 lbs. Troy.

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Moneys.	Weights and Measures.
	Capacity: Koku, Liquid = 10 To = 100 Sho = 39·7033 galls. Koku, Dry = 4·9629 bushels; Koku (capacity of vessel) $\frac{1}{10}$ ton. To, Liquid = 3·9703 galls.; To, Dry = 1.9851 peck.

Liberia.

English money chiefly used. Silver coins: 50, 25 and 10 cent pieces. Copper coins: 2 and 1 cents.	British weights and measures used.

Mexico.

Paper money only in circulation. 100 centavos = 1 dollar or peso (silver) = 2s. 0½d.	Metric system generally used in commerce; old Spanish Measures sometimes used are: 1 libra = 1·014 lb. av.; 1 arroba = 25 libras = 25·357 lbs. av.; 1 vara = 0·837 metre = 2 ft. $8\frac{2}{10}$ English inches; 1 legua comun = 6,666⅔ varas.

Monaco.

100 franc pieces.	Metric System.

Morocco.

6 floos = 1 blankeel, 4 blankeels = 1 ounce, 10 ounces = 1 mitkal = 4s. Hassani dollar = 100 mouzounis. Bronze coins: 10, 5 and 2 mouzounis.	*Length*: 1 Drah = 8 Tominis = 22 ins. *Weight*: 1 Kintar = 100 Rotals = 112 lbs. av. *Capacity*: 1 Tangier Mudd = 8 Tominis (abt.) = $1\frac{4}{10}$ bushels. 1 Kula (oil) = 28 Rotals = 47 lbs. = nearly 5½ Imp. galls.

Nicaragua.

Currency chiefly paper. Gold coins: 10, 5, 2½ and 1 cordoba = (4s. 1d.). Silver coins: 1s. 10d., 1s. 4d., 1s. 2d. and 1 cordoba.	Metric System.

Norway.

Currency chiefly paper; least value 5 kroner. 100 ore = 1 kroner = 1s. 1½d. Cold coins: 20 and 10 kroners.	Metric System.

Panama Republic.

Gold balboa or dollar = 4s. 1½d. Currency, silver dollar or peso = ½ balboa. Silver coins: ½, $\frac{1}{5}$, $\frac{1}{10}$ and $\frac{1}{20}$ peso pieces. U.S. currency legal tender.	1 Kilo = 2,204 lbs. = 100 kilos = approx. 1 ton. 1 Litre = 1·76 pints. English weights and measures also used.

Paraguay.

Currency, paper dollar = abt. 175 to the £.	Metric system. Argentine Republic weights and measures also used.

Persia.

1,000 dinars = 20 shahis = 1 kran = 4d. 60 krans = £1, and 390 krans = 100 rupees. Rate fluctuates. Gold coins: 10, 5, 2, 1, ½ and ¼ toman pieces. Gold toman = 22 krans. Silver coins: 5 and 10 shahis, 1, 2 and 5 krans. Silver toman = 10 krans.	Man-i-Tabriz = 8 Abbassis = 640 Miskals = 6·50 lb.; Man-i-Noh Abbassi = 9 Abbassis = 720 Miskals = 7·30 lbs.; Man-i-Kohneh = 1,000 Miskals = 10·14 lbs.; Man-i-Shah = 2 Tabriz Mans = 1,280 Miskals = 12·98 lbs.; Man-i-Rey = 4 Tabriz Mans = 2,560 Miskals = 25·96 lbs.;

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Moneys.	Weights and Measures.
	Man-i-Bender Abässî = 840 Miskals = 8·52 lbs.; Man-i-Hâshemî = 16 Mans of 720 Miskals = 116·80 lbs. Farsakh = 6,000 Zar of 40·95 inches = 3·87 miles. Jerib = 1,000 to 1,066 sq. Zar of 40·95 inches = 1,294 to 1,379 sq. yds.

Peru.

100 cents = 1 sol or dollar = 2s. abt. Gold coins: Libra = £, and 5 soles. Silver coins: 5, 10, 20 and 50 centavos, and 1 sol.	Metric System.

Philippine Islands.

U.S. coinage and Mexican dollar of 50 U.S. cents.	As U.S.

Portugal.

100 centavos = 1 escudo = 4s. 5½d. Currency principally paper. English gold legal tender = 4½ escudos to £. Gold coins: 2, 5 and 10 escudos. Silver coins: 1 escudo, 10, 20 and 50 centavos. Conto = 1,000 escudos.	Metric System.

Rumania.

1 leu = 100 bani = abt. 9½d. Silver coins: 1 leu, 2 and 5 lei. Nickel coins: 5, 10 and 20 bani. 25 lei 22 bani = £ (Exchange varies).	Metric System. Turkish weights and measures also used.

Russia.

100 copecks = 1 rouble. Abt. 13 roubles, silver or paper = £1. Currency chiefly paper. Gold coins: 15 roubles (Imperial), 10, roubles, 7·50 roubles (Half Imperial), 5 roubles. 15 paper roubles = 10 roubles gold.	*Length*: (Inch is similar to English inch). Verst (500 sajènes) = 3,500 ft.; Sajène (3 arshins) = 7 ft.; Arshin (16 vershok) = 28 inches; Sq. Verst = 281 acres = 0·43941 sq. miles; Dessiatine = 2·69972 acres. *Weight*: 1 pound (96 zolotniks = 32 lot) = $\frac{8}{10}$ lb.; 1 pood (40 pounds) = 36·113 lbs. = 0·32244 cwt. *Capacity*: 1 vedro (8 shtoffs) = 2¾ Imp. Gals.; 1 chetvert (8 chetveriks) = 5·77 Imp. Bushels or 46·2 gals.

St. Pierre and Miquelon.

Legal currency French, but U.S., Canadian, and Newfoundland money chiefly in use, together with gold coins of other countries. Fixed rates: 5 fr. 40 cents = $1, 26 fr.; $4 81½ c. = £1.	Metric System.

El Salvador.

100 centavos = 1 colon or dollar silver = abt. 2s. Silver coins: 5, 10, 20, 25 and 50 centavos. Nickel coins: 1, 3 and 5 centavos.	Metric system official and in general use.

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Moneys.	Weights and Measures.

Santo Domingo (Republica Dominicana).

U.S. gold dollar. Silver dollar= 1s. abt.	Metric System.

Servia.

Dinar=1 franc=9½d. Gold coins: 10 and 20 dinars. Silver coins: ½, 1, 2 and 5 dinars. Bronze coins: 5 and 10 paras. Nickel coins: 5, 10 and 20 paras.	Metric System.

Siam.

Silver tical=1s. 6½d. Gold coin= Dos=10 ticals; Satang=$\frac{1}{100}$ of a tical; tuang=2½d.; salung=4½d. Paper currency up to 1,000 ticals.	Metric System. Native measures are: *Length*: 1 Niu =·83 inches. 1 Keup=12 niu (10 inches). 1 Sok =2 keup (20 inches). 1 Wah =4 sok (80 inches.) 1 Sen =20 wah (133 feet). 1 Yot =400 sen (abt. 10 miles). *Weight*: 1 Chang (20 tamlungs)= 2 lbs. 10·3 ozs. av. (or 80 ticals) 50 Chang=1 hap=132¼ lbs.

Society Islands.

100 cents=1 dollar=3s. 11d. abt. U.S. and Mexican dollars and French 5 fr. pieces current at same rate.	

Spain.

100 centimos=1 peseta. 25·22 pesetas to £ sterling. Gold coins: 20, 10 and 5 peseta pieces. Silver coins: 1 and 5 pesetas.	Metric System.

Sweden.

Krone of 100 ore=1s. 1½d. 18·159 kr. to £. Currency chiefly paper (5 kr. and over).	Metric System.

Switzerland.

Franc=100 centimes=9·513d.	Metric System.

Tunis.

Same as France.	Same as France.

Turkey.

40 paras=1 piastre=2½d. nearly. 100 piastres=1 lira turca or gold medjidieh=18s. 110 piastres=£1. Purse=500 piastres=£4 10s. 0d.	*Length:* Arshin (Cloth measure)= 26·96 inches; Arshin (Land measure)=6·0548 sq. ft.; Deunüm (Land measure)=1098·765 sq. yds.; Djerib (hectare)=2·47 acres. *Weight:* Oke (400 drams)=2·8283 lbs. av.; Cantar (44 Okes)= 124·3616 lbs. av.; Tcheké (180 Okes)=508·75 pounds; Kileh (20 Okes)=0·36 Imp. qr.; 100 Kilehs =12·128 Imp. qrs.

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Moneys.	Weights and Measures.
	Capacity: Almud=1,151 Imp Gals.; Kileh=0·9120 Imp. Bushel. The Metric System is mostly employed. Roads and railways are marked in "kilometro."

United States.

1 cent=½d.; 10 cents=5d.; 1 dollar (100 cents)=4s. 1½d. Gold coins: 2½ dollar piece, half eagle (5 dollars), 1 eagle, and double eagle.	British weights and measures usually employed, except:— Wine gallon=0·83333 gallon; Ale gallon=1·01695 gallon; Bushel=0·9692 Imp. Bushel. Cental of 100 lbs.=British cwt.

Uruguay.

100 centavos=1 dollar (gold)=4s. 6d. Only foreign gold coins in circulation. Silver coins: 10, 20 and 50 cents and 1 dollar. Nickel coins: 1, 2 and 5 cents.	Metric System.

Venezuela.

Monetary Unit: Gold bolivar of 100 centésimos. Gold coins: 100, 20 and 10 bolivars; Silver coins: 25 and 50 cents, 1, 2 and 5 bolivars. Nickel coins: 5 and 12½ cents. Silver bolivar=9½d. Silver dollar of 5 bolivars (peso fuerte)=3s. 11½d.	Metric System.

West Indies, Guiana, etc. (French).

Same as France.	Metric System.

52.

53. SIZES OF BOOK AND DRAWING PAPERS.

Book Paper.

Book paper is usually folded to the following sizes (edges uncut). The most common size is crown 8vo.:—

	Inches.		Inches.
Demy 8vo.	8⅞×5⅝	Demy 16mo.	5⅛×4⅜
Post 8vo.	7⅜×5	Imperial 32mo.	5⅛×3⅛
Crown 8vo.	7½×5	Foolscap 12mo.	5⅛×3½
Demy 12mo.	7½×4⅜	Royal 32mo.	5 ×3½
Foolscap 8vo.	6⅝×4½	Demy 32mo.	4⅜×2½
Demy 18mo.	5⅞×3⅝	Crown 32mo	3½×2½

Drawing Paper.

	Inches.		Inches.
Demy	20×15½	Imperial	30×22
Medium	22×17½	Double Elephant	40×26½
Royal	24×19½	Antiquarian	52½×30½

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54. ROMAN NUMERALS.

I	1	LXX	70
II	2	LXXX	80
III	3	LXXXVIII	88
IV	4	XC	90
V	5	XCIX	99
VI	6	C	100
VII	7	CX	110
VIII	8	CXI	111
IX	9	CXC	190
X	10	CC	200
XI	11	CCXX	220
XII	12	CCXXIV	224
XIII	13	CCC	300
XIV	14	CCCXX	320
XV	15	CD	400
XVI	16	D	500
XVII	17	DC	600
XVIII	18	DCCC	800
XIX	19	DCCCLXXVI	876
XX	20	CM	900
XXX	30	CMXCIX	999
XL	40	M	1,000
L	50	MD	1,500
LV	55	MDCCC	1,800
LX	60	MM	2,000

55. SUNRISE AND SUNSET.

See page 281.

56. RELATIVE RANKS.

Air Force.	*Army.*	*Navy.*
Marshal of the Air.	Field Marshal.	Admiral of the Fleet.
Air Chief Marshal.	General.	Admiral.
Air Marshal.	Lieut.-General.	Vice-Admiral.
Air Vice-Marshal.	Major-General.	Rear Admiral.
Air Commodore.	Col.-Commandant.	Commodore.
Group Captain.	Colonel.	Captain of 3 years' seniority.
Wing Commander.	Lieut.-Colonel.	Captain under 3 years, and *Commander.
Squadron Leader.	Major.	Lt.-Commander.
Flight Lieut.	Captain.	Lieutenant.
Flying Officer.	Lieutenant.	Sub-Lieut.
Pilot Officer.	2nd Lieut.	Midshipman.

* Commanders, Royal Navy, rank with, but are junior to, Wing Commanders in the Royal Air Force and Lieut.-Colonels in the Army.

Note.—The expression "Air Officer" corresponds with "General Officer" in the Army and "Flag Officer" in the Navy.

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55.—SUNRISE AND SUNSET.

Mean local times for all places on Greenwich Meridian between latitudes 60° N. and 40° S.

Note.—For places east or west of Greenwich the following corrections must be made to figures given :—
Deduct 4 mins. for each degree of longitude E. of Greenwich. Add 4 mins. for each degree of longitude W. of Greenwich.

Latitude.	60° N.		50° N.		40° N.		30° N.		20° N.		10° N.		Equator.		10° S.		20° S.		30° S.		40° S.	
	rises.	sets.	rises.	sets.	rises.	sets.	rises.	sets.	rises.	sets.	rises.	sets.	rises.	sets.	rises.	sets.	rises.	sets.	rises.	sets.	rises.	sets.
	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
January 1 -	9 7	2 59	8 1	4 57	7 23	4 43	6 57	5 9	6 36	5 30	6 18	5 48	6 1	6 5	5 44	6 22	5 25	6 41	5 4	7 2	4 36	7 30
„ 16 -	8 52	3 28	7 56	4 24	7 22	4 58	6 59	5 21	6 40	5 49	6 23	5 57	6 8	6 12	5 52	6 28	5 35	6 45	5 16	7 4	4 52	7 28
February 1 -	8 20	4 8	7 37	4 51	7 11	5 17	6 53	5 35	6 38	5 50	6 24	6 4	6 12	6 16	5 58	6 29	5 45	6 43	5 30	6 58	5 11	7 17
„ 16 -	7 40	4 48	7 11	5 17	6 54	5 34	6 40	5 48	6 30	5 58	6 21	6 7	6 12	6 16	6 2	6 26	5 53	6 35	5 42	6 46	5 28	7 0
March 1 -	7 3	5 22	6 47	5 39	6 36	5 49	6 28	5 57	6 22	6 4	6 16	6 9	6 10	6 14	6 5	6 20	5 59	6 26	5 52	6 33	5 44	6 42
„ 16 -	6 19	5 59	6 15	6 3	6 13	6 5	6 11	6 7	6 10	6 8	6 8	6 1	6 7	6 11	6 5	6 13	6 4	6 14	6 2	6 16	6 0	6 18
April 1 -	5 30	6 38	5 40	6 28	5 47	6 21	5 52	6 16	5 56	6 12	5 59	6 9	6 2	6 6	5 6	6 3	6 8	6 0	6 12	5 56	6 16	5 52
„ 16 -	4 45	7 15	5 8	6 52	5 23	6 37	5 34	6 26	5 43	6 17	5 51	6 9	5 58	6 2	5 5	5 55	6 12	5 48	6 21	5 39	6 31	5 29
May 1 -	4 2	7 52	4 39	7 15	5 2	6 52	5 19	6 35	5 32	6 22	5 44	6 10	5 55	5 59	6 6	5 48	6 17	5 37	6 30	5 24	6 46	5 8
„ 16 -	3 24	8 28	4 15	7 37	4 46	7 6	5 8	6 44	5 25	6 27	5 40	6 12	5 54	5 58	6 8	5 44	6 22	5 30	6 39	5 13	7 0	4 52
June 1 -	2 54	9 2	3 59	7 57	4 36	7 20	5 1	6 55	5 21	6 35	5 39	6 17	5 55	6 0	6 12	5 44	6 29	5 26	6 49	5 6	7 14	4 42
„ 16 -	2 40	9 20	3 52	8 4	4 32	7 28	5 0	7 0	5 21	6 39	5 41	6 19	5 58	6 2	6 15	5 45	6 34	5 26	6 55	5 7	7 22	4 38
July 1 -	2 44	9 22	3 56	8 10	4 35	7 31	5 3	7 3	5 25	6 41	5 44	6 22	6 1	5 6	6 18	5 48	6 36	5 30	6 58	5 8	7 24	4 42
„ 16 -	3 7	9 4	4 10	8 2	4 46	7 26	5 10	7 1	5 30	6 41	5 47	6 24	6 4	6 8	6 19	5 52	6 36	5 35	6 56	5 16	7 20	4 52
August 1 -	3 42	8 30	4 30	7 42	4 59	7 13	5 20	6 52	5 36	6 36	5 51	6 21	6 4	6 8	6 17	5 55	6 31	5 41	6 47	5 25	7 8	5 4
„ 16 -	4 18	7 50	4 52	7 16	5 13	6 55	5 28	6 40	5 41	6 27	5 52	6 16	6 2	6 6	6 12	5 56	6 23	5 45	6 35	5 33	6 49	5 19
Sept. 1 -	4 55	7 5	5 15	6 45	5 28	6 32	5 38	6 22	5 45	6 15	5 51	6 9	5 58	6 2	6 4	5 56	6 10	5 50	6 17	5 43	6 26	5 34
„ 16 -	5 31	6 19	5 37	6 13	5 42	6 8	5 46	6 4	5 48	6 2	5 51	5 59	5 53	5 57	5 55	5 55	5 57	5 53	6 0	5 50	6 2	5 48
October 1 -	6 6	5 37	6 0	5 40	5 57	5 43	5 55	5 45	5 52	5 48	5 50	5 50	5 48	5 52	5 46	5 54	5 43	5 57	5 41	5 59	5 37	6 3
„ 16 -	6 43	4 49	6 24	5 8	6 13	5 19	6 4	5 28	5 56	5 36	5 50	5 42	5 44	5 48	5 37	5 55	5 31	6 1	5 23	6 9	5 14	6 18
Nov. 1 -	7 23	4 5	6 51	4 37	6 30	4 58	6 15	5 13	6 3	5 25	5 52	5 36	5 42	5 46	5 32	5 56	5 21	6 7	5 8	6 20	4 52	6 36
„ 16 -	8 2	3 28	7 16	4 14	6 48	4 42	6 27	5 3	6 11	5 19	5 56	5 34	5 43	5 47	5 29	6 1	5 14	6 16	4 58	6 32	4 37	6 53
Dec. 1 -	8 37	3 1	7 38	4 0	7 4	4 34	6 39	4 59	6 20	5 18	5 3	5 35	5 47	5 51	5 30	6 8	5 13	6 25	4 53	6 45	4 28	7 10
„ 16 -	9 2	2 49	7 54	3 57	7 17	4 34	6 51	5 1	6 29	5 22	5 11	5 41	5 54	5 58	5 37	6 15	5 17	6 34	4 56	6 56	4 28	7 24

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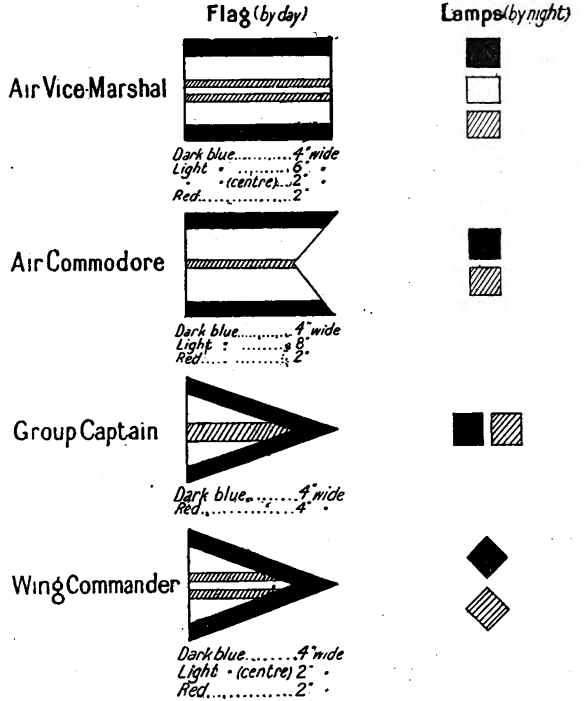
Flag (by day)
Lamps (by night)
Air Vice-Marshal
Dark blue.....4" wide
Light " .....6" "
" " (centre)..2" "
Red.....2"
Air Commodore
Dark blue.....4" wide
Light " .....8" "
Red.....2"
Group Captain
Dark blue.....4" wide
Red.....4" "
Wing Commander
Dark blue.....4" wide
Light " (centre) 2" "
Red.....2" "
Note.-The size of the above flags is not to exceed 3' long and 2'2" wide.
Squadron Leader
12
Number denotes squadron or park numeral. Number not to be used in E.F. areas.
Dark blue.....3" wide
Light " .....6" "
Red.....2" "
Note. The size of the Squadron Leader flag is not to exceed 2'6" long and 1'8" wide.
R.A.F. Colours
Dark blue shown thus
Red " "
Light " "

FIG. 111.

FIG. 111.

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Rank.	French Army.¶ On Sleeve.	German Army. On Shoulder Strap.	Belgian Army.‡ On Collar.	U.S. Army.§ On Shoulder Strap.
General	—	Gold and silver twist, 2 stars.	—	Coat of arms and 2 stars.
Lieut.-General	3 small gold stars*	Gold and silver twist, 1 star.	2 vertical gold lace stripes, 3 gold stars, gold thunderbolt.	1 large, 2 small stars.
Major-General	2 small gold stars*	Gold and silver twist, no star.	2 vertical gold lace stripes, 2 gold stars, gold thunderbolt.	2 stars.
Colonel	5 gold bars†	Silver twist, 2 stars	1 vertical gold lace stripe, 3 gold stars.	1 silver spread eagle.
Lieut.-Colonel	3 gold and 2 silver bars	Silver twist, 1 star	1 vertical gold lace stripe, 2 gold stars.	1 silver leaf.
Major	4 gold bars†	Silver twist, no star	1 vertical gold lace stripe.	1 gold leaf.
Captain	3 gold bars†	Straight silver cord, 2 stars	3 gold stars	2 silver bars.
Lieutenant	2 gold bars†	Straight silver cord, 1 star.	2 gold stars	1 silver bar.
2nd Lieutenant	1 gold bar†	Straight silver cord, no star.	1 gold star	No badge.
Warrant Officer	1 silver bar, red striped	—	1 silver star	—
Sergeant-Major Feldwebel.	2 broad gold bars†	Gold or silver collar lace, button either side.	2 brown rings on cuff and 2 brown stripes above elbow.	—
Sergeant	1 broad gold bar	Plain collar lace, button either side.	1 narrow brown ring on cuff.	—
Corporal Unter-offizier.	2 dark blue woollen bars	Collar lace	1 broad brown ring on cuff.	—
Private Gefreiter.	1 dark blue woollen bar	Button either side of collar.	—	—
Bugler	Red, white and blue bar	Cord " wings " on shoulders.	—	—

¶ The bars (" galons ") are about 2 inches long; horizontal for officers; oblique for N.C.O's.

* Generals also wear these stars on front of képi throughout Army (otherwise grey-blue képi shows no badge rank), and double dark blue piping to breeches.

† Silver for Cavalry and Chasseurs. ‡ The same badges of rank are worn on the overcoat.

§ On overcoat: General to Brig.-General wear the badge of rank in dull bronze below the elbow, with two bands of black braid, one above, one below badge; Colonel, 5 bands; Lieut.-Colonel, 4; Major, 3; Captain, 2; Lieutenant, 1; 2nd Lieutenant, no bands.

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58.—THERMOMETERS.

To convert Fahrenheit to Centigrade deduct 32 and multiply by $\frac{5}{9}$.
To convert Centigrade to Fahrenheit multiply by $\frac{9}{5}$ and add 32.

Centi-grade.	Fahrenheit.	Centi-grade.	Fahrenheit.	Centi-grade.	Fahrenheit.
−0	32·0	21	69·8	41	105·8
+1	33·8	22	71·6	42	107·6
2	35·6	23	73·4	43	109·4
3	37·4	24	75·2	44	111·2
4	39·2	25	77·0	45	113·0
5	41·0	26	78·8	46	114·8
6	42·8	27	80·6	47	116·6
7	44·6	28	82·4	48	118·4
8	46·4	29	84·2	49	120·2
9	48·2	30	86·0	50	122·0
10	50·0	31	87·8	55	131·0
11	51·8	32	89·6	60	140·0
12	53·6	33	91·4	65	149·0
13	55·5	34	93·2	70	158·0
14	57·2	35	95·0	75	167·0
15	59·0	36	96·8	80	176·0
16	60·8	37	98·6	85	185·0
17	62·6	38	100·4	90	194·0
18	64·4	39	102·2	95	203·0
19	66·2	40	104·0	100	212·0
20	68·0				

60.—DISTINGUISHING FLAGS AND LAMPS.

Flags.

Hospital :

7 ft. 6 in. × 7 ft. 6 in. — Field ambulances
6 ft. × 4 ft. — Except field ambulances
} White with red cross.

Latrine :

British : 3 ft. × 2 ft., yellow with white ball.
Native : 3 ft. × 2 ft., yellow with black ball.

Water Supply :

Red
White
} Shallon, 2 ft. 6 in. × 4 ft 2 in. { For washing or bathing. For drinking water.

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63. IDENTIFICATION MARKS ON AIRCRAFT.

Country.	Fuselage (both sides).	Lower Plane (on bottom).	Upper Plane (on top).	Rudder (both sides).
America (United States of).	- - - - -	White 5 pointed star with red centre inset in blue circle.	White 5 pointed star with red centre inset in blue circle.	
Austria - - -	Black Maltese crosses -	Black Maltese crosses -	Red, white, and red stripes in a fore and aft direction at each wing tip.	Red, white, and red vertical stripes on both sides of the rudder.
Belgium - - -	Three concentric circles —inner circle black, middle circle yellow, and outer circle red.	Three concentric circles —inner circle black, middle circle yellow, and outer circle red.	Three concentric circles —inner circle black, middle circle yellow, and outer circle red.	Three vertical stripes of equal width — red, yellow, and black, the red stripe being next to the rudder post. These markings are displayed on both sides of the rudder.
Brazil - - -	- - - - -	Three concentric circles —centre blue, middle red, outer yellow.	Three concentric circles —centre blue, middle red, outer yellow.	Three vertical stripes, blue, yellow and green.
Bulgaria - - -	Black Maltese crosses -	Black Maltese crosses -	Black Maltese crosses, with green band along the trailing edge.	Black Maltese crosses on both sides.

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Country.	Fuselage (both sides).	Lower Plane (on bottom).	Upper Plane (on top).	Rudder (both sides).
China - - -	Chinese numerals -	Five-pointed star, each point different colour —red, yellow, blue, white, black.	Nil.	Arabic numeral on both sides.
Denmark - - -	Nil.	Circular discs, outer ring red, whole inner portion white.	Circular discs, outer ring red, whole inner portion white.	Circular disc, outer ring red, whole inner portion white, on both sides.
France - - -	Three concentric circles —inner circle blue, middle circle white, and outer circle red.	Three concentric circles —inner circle blue, middle circle white, and outer circle red.	Three concentric circles —inner circle blue, middle circle white, and outer circle red.	Three vertical equal stripes, blue, white, and red, on both sides, the blue stripe being next to the rudder post.
Germany - - -	Black Maltese crosses -	Black Maltese crosses -	Black Maltese crosses -	Black Maltese crosses on both sides.
Great Britain - -	Three concentric circles —inner circle red, middle circle white, and outer circle blue.	Three concentric circles —inner circle red, middle circle white, and outer circle blue.	Three concentric circles —inner circle red, middle circle white, and outer circle blue.	Three vertical equal stripes, blue, white, and red, on both sides, the blue stripe being next to the rudder post.
Greece - - -	Nil.	Triple ring—light blue, white, light blue.	Triple ring—light blue, white, light blue.	Three vertical equal stripes, light blue, white, and red on both sides, the blue stripe being next to the rudder post.
Holland - - -	Orange circle - -	Orange circle - -	Orange circle -	Orange circle on both sides.

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Italy - - -	Three concentric circles —inner circle green, and middle circle white, and outer circle red (or inner circle red, middle circle white, and outer circle green).	Three equal stripes—outer green, centre white, and inner red.	Three concentric circles —inner circle green, middle circle white, and outer circle red (or inner circle red, middle circle white and outer circle green).	Three equal vertical stripes, red, white, green, the red stripe being next to the rudder post.
Japan - - -	Nil.	All red disc - -	All-red disc - -	Arabic numeral on both sides.
Norway - - -	Nil.	Vertical stripes—two outer stripes red, next stripes white, and inner stripe dark blue.	Vertical stripes—two outer stripes red, next stripes white, and inner stripe dark blue.	Black numbers on both sides, odd numbers being used for military machines preceded by letter F, and even numbers for naval machines. Some naval machines have Norwegian colours on both sides of the rudder.
Portugal - - -	Nil.	Red circle, green centre	Red circle, green centre	Three equal vertical stripes — green, red, green, on both sides, green stripe being next to rudder post.
Russia (Naval) -	Nil.	Three concentric circles —inner circle white, middle circle blue, and outer circle red.	Three concentric circles —inner circle white, middle circle blue, and outer circle red.	St. Andrew's Cross in blue on both sides.
Russia (Military) -	Nil.	Three concentric circles —inner circle white, middle circle blue, and outer circle red.	Three concentric circles —inner circle white, middle circle blue, and outer circle red.	Three concentric circles —inner circle white, middle circle blue, and outer circle red.
Spain - - -	Nil.	Three equal vertical stripes, red outside, yellow centre, red inside.	Nil.	Three equal vertical stripes, red outside, yellow centre, red inside.

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63. IDENTIFICATION MARKS ON AIRCRAFT—*continued.*

Country.	Fuselage (both sides).	Lower Plane (on bottom).	Upper Plane (on top),	Rudder (both sides).
Sweden - - -	Number of machine in large block lettering.	Three black crowns on a white ground, also number of machine in large black letters.	Three black crowns on a white ground.	Swedish flag on both sides.
Switzerland - -	Nil.	White cross on red background.	White cross on red background.	White cross on red background (on both sides of rudder).
Turkey - - -	White square, within which is black square about three-quarters of the size of white square.	White square, within which is black square about three-quarters of the size of white square.	White square, within which is black square about three-quarters of the size of white square.	White square, within which is black square about three-quarters of the size of white square.

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AERONAUTICAL TERMS.

English Term.	Definition.	French Equivalent.
Altimeter	An aneroid barometer graduated to show height instead of pressure.	Altimètre.
Rate of climb	—	Vitesse de montée ou vitesse ascensionnelle.
Longitudinal stability.	(Where separable from the lateral stability.) The stability of the motions in the plane of symmetry, *i.e.*, of the rise and fall, forward motion and pitching.	Stabilité longitudinale.
Lateral stability	(Where separable from the longitudinal stability.) The stability of the motions out of the plane of symmetry, *i.e.*, of side-slipping, rolling and yawing.	Stabilité latérale.
Magnetic storms	—	Orages magnétiques.
Performance	The term for the speed rate of climb and ceiling reached by an aircraft under given conditions of load.	Performance.
Ceiling	The limit of height to which an aircraft can climb.	Plafond.
Dive	To descend steeply with the nose of the aircraft down.	Piquer.
Spinning dive	A diving descent combined with a continued rotation about the direction of motion of the centre of gravity of an aeroplane.	Descente en vrille.
Stalling	An aeroplane is said to be stalled when the speed is so reduced that it ceases to be under control. This occurs when the angle of incidence is in excess of the critical angle.	Etre en perte de vitesse.
Rolling	Angular motion about the longitudinal axis. A roll is a complete revolution about that axis.	Roulis.
Pitching	Angular motion about the lateral axis. A loop is a complete revolution about that axis.	Tangage.
Yawing	Angular motion about the normal axis. A spin is a complete revolution about that axis.	Lacet.
To bank	To heel for the purpose of turning (*cf.* "Rolling").	Pencher.
To side-slip	In an aircraft, to move more or less broadside on relatively to the air.	Glisser sur l'aile ou déraper.
To drift	To be carried by a current of air or water; to make leeway.	Aller à la dérive, dériver.
Leeward	Away from the wind	Sous le vent.
Aeroplane	—	Aéroplane.
Plane	Strictly, a perfectly flat surface, but colloquially applied to an aerofoil or surface of an aeroplane and sometimes to the whole machine, as in seaplane, warplane, waterplane, etc.	Plan.
Monoplane	An aeroplane with one main supporting surface.	Monoplan.

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English Term.	Definition.	French Equivalent.
Tractor monoplane.	A monoplane with the airscrew mounted in front of the main supporting surface.	Monoplan tracteur, ou à hélice tractive.
Biplane	An aeroplane with two main supporting surfaces.	Biplan.
Tractor biplane	A biplane with the airscrew mounted in front of the main supporting surfaces.	Biplan tracteur, ou là hélice tractive.
Pusher biplane	A biplane on which the main supporting surfaces are in front of the airscrew.	Biplan propulseur, ou à hélice propulsive.
Triplane	A machine with three main supporting surfaces.	Triplan.
Tractor triplane	A triplane with the airscrew mounted in front of the main supporting surfaces.	Triplan tracteur, ou à hélice tractive.
Pusher triplane	A triplane on which the main supporting surfaces are in front of the airscrew.	Triplan propulseur, ou à hélice propulsive.
Wing	—	Aile.
Gap	The distance between the top and bottom main supporting surfaces of a biplane.	Écartement.
Sweepback	The angular set back of the main planes relatively to the main body.	Ailes fuyantes.
Stagger	—	Décalage (des ailes).
Dihedral angle	—	Dièdre latéral.
Incidence (rigging)	The angle between the chord of a main plane and the horizontal when the aeroplane is in the rigging position.	Incidence (au montage).
Rigging position of an aeroplane.	Position in which an arbitrary datum plane fixed in regard to the aeroplane is horizontal.	Position de montage.

AIRCRAFT COMPONENTS.

Chock	—	Cale.
Clips	—	Pattes.
Hinge Clip	—	Patte à charnière.
Wiring Clip	—	Patte à tendeur.
Wiring Clip Ferrule.	—	Œillet de patte à tendeur.
Cock	—	Robinet.
Cotter	—	Clavette.
Dowel	—	Cheville de repérage.
Eyelets	—	Œillets.
Eyebolts	—	Boulons à œil.
Fairing	A piece added to any structure to reduce its head resistance or drag.	Ajoute profilé. Manchon profilé.
Filter	—	Filtre.
Flange	—	Rebord, latte.
Flexible connection.	—	Transmission flexible.
Fitting	A generic term for any small metal parts.	Ferrure.
Fork joints	—	Chape.
Gland	—	Gland.
Grease cup	—	Graisseur.
Gusset plate	—	Gousset.

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English Term.	Definition.	French Equivalent.
Gasket	A metal and asbestos joint	Joint d'amiante.
Joint	—	Joint.
Key	—	Clavette.
King post	The main compression member of a stiffening system applied to a member subject to bending.	Pylone; guignol.
Lubricator	—	Lubrifiant.
Locking wires	—	Freins annulaires.
Locking nuts	—	Contre-écrous.
Lug	—	Patte.
Nut	—	Ecrou.
Hexagon nut	—	Ecrou à 6 pans.
Union nut	—	Ecrou de joint.
Wing nut	—	Ecrou à oreilles ou écrou papillon.
Olive joint	—	Joint ovale.
Packing	—	Bourrage.
Packing plate	—	Plaque de bourrage.
Pin	—	Axe.
Plug	—	Bouchon bougie.
Pipe	—	Tuyau.
Rivet	—	Rivet.
Rib	A light member which gives the desired shape to the outer fabric, or covering material, of a structure.	Nervure.
Compression rib	A member which assists to give the desired shape to the outer covering of a structure, and, at the same time, acts as a strut between the spars of that structure.	Nervure principale.
Form rib	Colloq. nose rib, riblet, former rib	Bord d'attaque proprement dit.
Main rib	—	Nervure principale.
Shackles	—	Jumelle.
Socket	—	Douilles.
Screw (metal)	B.A., B.S.F., Whitworth or International (metric).	Vis (métal).
Wood Screw	—	Vis à bois.
Spring	—	Ressort.
Split pins	—	Goupilles fendues.
Spar	A spar is a principal member of a structure, or a portion of a structure. It supports subordinate members and is principally subjected to bending stresses.	Longeron.
Stay	—	Montant ou tirant.
Streamline wires	—	Haubans fuselés.
Strut	A structural member intended to resist compression in the direction of its length.	Mât.
Struts, centre, fore and aft.	—	Mâts, centraux, avants ou arrières.
Struts, interplane, fore and aft.	Numbered from fuselage outwards. Excluding struts belonging to centre main portion.	Mâts, intérieurs avants ou arrières.
Struts, interplane, intermediate.	—	Mâts, intérieurs. Mâts, intermédiaires.
Colloquially: Struts, front and rear body.	—	Mâts de corps, avants, arrières.

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English Term,	Definition.	French Equivalent.
Struts, centre section.	—	Mâts de la section centrale ou mâts de cabane.
Struts, nacelle -	—	Mâts de nacelle.
Struts, fuselage	—	Mâts de fuselage.
Struts, outer main.	—	Mâts principaux extérieurs.
Struts may be of the following types :—		
King post, vertical, cross or diagonal.	—	Pylone, vertical, oblique ou diagonal.
Main plain centre section struts.	Struts connecting the fuselage or nacelle to the planes.	Mâts de la section centrale ou mâts de cabane.
Interplane struts-	—	Mâts intérieurs.
Stiffener - -	A part used for reinforcing a member or system of members.	Membre de renfort, ou pièce de renforcement.
Stud - - -	—	Plot.
Support - -	—	Support.
Swaged wires -	—	Tendeurs à bout fileté.
Taper pins - -	—	Axes coniques.
Turnbuckles -	—	Tendeur à manchon
End rib - -	—	Nervure de sortie.
Union - -	—	Raccord; joint.
Universal fork joints.	—	Joint à la cardan.
Washer - -	—	Rondelle.
Spring washer -	—	Rondelle grover.
Fibre washer -	—	Rondelle souple.
Body, nacelle, fuselage, cockpit.	—	*Carrosserie, nacelle, fuselage.*
Nacelles for engines.	—	Nacelles de moteurs
Nacelles for passengers.	—	Nacelles pour passagers.
Nacelles for passengers and engines.	—	Nacelles pour passagers et moteurs.
Fuselage - -	—	Fuselage.
Cockpit - -	—	Nacelle.
Fuselage main framework.	—	*Membrure principale de fuselage.*
Longitudinals -	Of an aeroplane—the long fore and aft spars connecting the main with the subsidiary supporting or controlling surfaces.	Longerons de fuselage.
Longeron - -	*See* "Longitudinals" - -	Longeron.
Fuselage bracing.	—	*Haubanages.*
Wires, bulkhead -	Wires by which the fuselage is braced in planes at right angles to its length. Colloq., Internal bracing wires.	Croisillons.
Main planes -	—	*Plans sustentateurs principaux.*
Main top planes	—	Plans supérieurs.
Main top planes, starboard.	—	Plans supérieurs, tribord.
Main top planes, port.	—	Plans supérieurs, bâbord.

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English Term.	Definition.	French Equivalent.
Main top planes, starboard, inner (or outer).	—	Plans supérieurs, tribord, intérieurs ou extérieurs.
Main top planes, port, inner (or outer).	—	Plans supérieurs, bâbord, intérieurs ou extérieurs.
Main top planes, centre.	—	Plans supérieurs, section centrale.
Main bottom planes.	—	Plans inférieurs.
Main bottom planes, starboard.	—	Plans inférieurs, tribord.
Main bottom planes, port.	—	Plans inférieurs, bâbord.
Main bottom planes, starboard, inner (or outer).	—	Plans inférieurs. tribord, intérieurs ou extérieurs.
Main bottom planes, port, inner(or outer)	—	Plans inférieurs,bâbord, intérieurs ou extérieurs.
Main bottom planes, centre.	—	Plans inférieurs, centraux.
Main middle plane.	In a triplane, the plane between the top and bottom.	Plan sustentateur principal moyen.
Ailerons - -	—	Ailerons.
Ailerons, top and bottom.	Colloquially—wing flaps, balancing flap.	Ailerons supérieurs, inférieurs.
Aileron lever -	Colloquially—aileron king post -	Guignol d'aileron.
Lift wires - -	Wires, the principal function of which is to transfer the lift of the wings to the body or other part of the aeroplane structure.	Haubans inférieurs.
Flying wires -	A term for wires for bearing the main load of an aeroplane in the air.	Haubans ou cordes à piano.
Warp wires -	Lift wires connected to the back spar and controlled so as to move its outer end down for the purpose of warping the wing.	Haubans arrières de gauchissement.
Anti-lift wires -	Wires intended mainly to resist forces in the opposite direction to the lift. Also called "anti-flying wires."	Haubans supérieurs.
Top warp wires -	A colloquial term for top load wires connected to the back spar and passing from wing to wing to allow the wings to warp.	Haubans supérieurs de gauchissement.
Landing wires -	—	Haubans supérieurs
Drag wires - -	Wires, the principal function of which is to transfer the drag of the wings to the body or other part of the aeroplane structure.	Haubans de trainée Haubans de recul.
Incidence wires -	—	Croisillons d'incidence ou d'attaque ou haubans d'attaque.
Wiring lug - -	—	Douille.
Tail - - -	—	*Empennage.*
Tail - - -	—	Empennage.
Tail booms -	—	Longerons de la poutre de liaison.

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English Term.	Definition.	French Equivalent.
Tail girder	—	Poutre de liaison.
Tail plane	—	Plan stabilisateur de l'empennage.
Stay tubes	Tail plane	Tube soutient d'empennage.
Elevator	—	Gouvernail de profondeur.
Elevator lever	Colloquially—elevator king post	Guignol du gouvernail d'altitude.
Fins	Subsidiary aerofoils set parallel to the normal direction of motion of an aircraft.	Plans de dérive.
Fin post	—	Etambot.
Rudder	—	Gouvernail de direction.
Stern post	Colloquially—Fin post, rudder post.	Etambot.
Flying Controls.	—	*Commandes.*
Control column	—	Levier de commande.
Elevator control lever.	Colloquially, Bloater elevator, cross shaft.	Levier de commande du gouvernail de profondeur.
Control wire	—	Câble de commande
Tail plane actuating gear.	—	Dispositif d'ajustage du dièdre longitudinal.
Rudder bar	—	Palonnier.
Airscrews	—	*Hélices.*
Airscrew	—	Hélice.
Propeller	An airscrew mounted behind the main supporting surfaces.	Hélice propulsive.
Tractor	An airscrew mounted in front of the main supporting surfaces.	Hélice tractive.
Right-hand airscrew.	An airscrew which revolves so that when in progression the path of any point of a blade describes a right-hand helix in the air.	Hélice à pas à droite.
Left-hand airscrew.	An airscrew which revolves so that when in progression the path of any point of a blade describes a left-hand helix in the air	Hélice à pas à gauche.
Undercarriage.		*Chassis d'atterrissage.*
Undercarriage	—	Chassis d'atterrissage. Chassis d'amerrissage.
Wheels	—	Roues.
Tyre covers	—	Pneumatique.
Tyre tubes	—	Chambres à air.
Wheel disc	Colloquially—Fairing for heels, Disc for wheels.	Blindage de roue.
Axle	—	Axe de moyeu-Essieu.
Cord, shock absorber.	Colloquially—Sandow	Amortisseur à corde élastique. Sandow.
Floats	Watertight compartments of suitable shape carried by seaplanes.	Flotteurs.
Skid (under-carriage).	—	Patin.
Tail skid	—	Béquille.

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AIRCRAFT INSTRUMENTS AND APPARATUS.

English Term.	Definition.	French Equivalent.
Position.		*Gisement.*
Sextant	—	Sextant.
Azimuth finder	—	Cercle azimutal.
Bombsight	—	Viseur.
Drift indicator	—	Indicateur de dérive.
Speed.		*Vitesse.*
Ground speed indicator.	—	Indicateur de vitesse par rapport au sol.
Air speed indicator.	—	Indicateur de vitesse par rapport à l'air.
Anemometer	An instrument for measuring the velocity or force of the wind.	Anémomètre.
Pilot tube	—	Tube de pitot.
Float seaplane	An aeroplane provided with floats for alighting on water.	Hydravion.
Boat seaplane	An aeroplane of which the main body is also a support on the water.	Avion monocoque.
Parachutes	—	Parachutes.
Aerodromes	—	Aérodromes.
Buildings	—	Bâtiments.
Hangars	—	Hangars.
Lighthouses, guides	—	Phares, Point de repérage.
Telegraphic apparatus.	—	Appareil télégraphique.
Different telegraphic systems.	—	Systèmes télégraphiques divers.
Wireless	—	Télégraphie sans fils.
Printing systems	—	Télégraphe à lecture directe.
Establishment of telegraphic lines.	—	Etablissement de lignes télégraphiques.
Submarine cables	—	Câbles sousmarine.
Submarine telegraphy.	—	Télégraphie sousmarine.
Telephony	—	Téléphonie.
Wireless telephony	—	Téléphonie sans fil.
Bells	—	Cloches.
Acoustic tubes, speaking tubes.	—	Tubes acoustiques.

TYPES OF AIRCRAFT INTERNAL COMBUSTION ENGINES.

English Term.	Definition.	French Equivalent.
Tractor engine	An engine which has the airscrew mounted in front when in position in an aircraft.	Moteur tracteur.
Pusher engine	An engine which has the airscrew mounted at the rear end when in position in an aircraft.	Moteur propulseur.
Right-hand engine.	An engine designed to drive a right-hand tractor airscrew.	Moteur droitier, ou tournant à droite.
Left-hand engine	An engine designed to drive a left-hand tractor airscrew.	Moteur gaucher, ou tournant à gauche

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English Term.	Definition.	French Equivalent.
Horizontally opposed engine.	An engine having its cylinder axes lying in a horizontal plane, the cylinders being arranged in pairs opposite each other, their connecting rods working on the same crankshaft.	Moteurs à cylindres horizontaux opposés.
Radial engine -	An engine having its cylinders arranged around a common crank in the form of a star, the cylinders being stationary and crankshaft revolving.	Moteur en étoile ou Moteur radiostatique.
Rotary engine -	An engine having its cylinders arranged around a common crank in the form of a star, the cylinders revolving and crankshaft stationary.	Moteur rotatif.
Inverted engine -	An engine having its cylinder axes in the vertical plane, but arranged below the crankshaft.	Moteur renversé.
Vertical engine -	An engine having its cylinder axes upright and in the same plane.	Moteur à cylindres verticaux.
Vee-type engine -	An engine having its cylinders arranged in two rows, forming in the end view the letter "V."	Moteur en V.
Arrow engine -	An engine with three rows of cylinders.	Moteur en flèche.
Supercharger engine.	This term is used when the cylinders are charged with a greater weight of charge than would be induced normally at atmospheric pressure.	Moteur suralimenté.
Differential engine.	An engine in which the cylinders and crankshaft revolve in an opposite sense.	Moteur bi-rotatif.

ENGINE COMPONENTS.

English Term.	Definition.	French Equivalent.
Normal horse-power of an engine.	The highest horse-power which can be safely maintained for long periods (b.h.p.).	Puissance normale d'un moteur (h.p. au frein).
Dry weight -	The weight of an engine including magnetos, carburettors and propeller hub, but excluding exhaust manifold, oil and water.	Poids à vide.

Component Parts of Engines.

The following and similar parts should take the name of the piece or pieces to which or in which they are fitted:—

English Term.	French Equivalent.	English Term.	French Equivalent.
Bolt - -	Boulon.	Filter - -	Filtre.
Cap - -	Bouchon.	Flange - -	Bride, flasque, joue.
Circlip - -	Collier de serrage.	Flexible connection.	Accouplement élastique.
Clamp - -	Etrier.	Gasket (a metal and asbestos joint).	Joint à l'amiante roudelle souple.
Clip - -	Patte d'attache.		
Cock - -	Robinet.		
Cotter - -	Clavette.		
Dowel - -	Cheville.		

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English Term.	French Equivalent.	English Term.	French Equivalent.
Gear wheel, driven.	Roue dentée, (entrainée ou libre).	Pin - - -	Axe, goupille.
Gear wheel, driving.	Roue dentée (motrice).	Pinion - -	Pignon.
Gland - -	Gland.	Pipe - -	Tuyau.
Grease cup -	Graisseur.	Plug - -	Bougie, bouchon.
Joint - -	Rotule.	Rivet - -	Rivet.
Key - -	Clavette.	Screw - -	Vis.
Leather cover -	Cuir embouti.	Shims - -	Cale.
Lubricator -		Snug - -	
Nipple - -	Nipple.	Spring - -	Ressort.
Nut - - -	Ecroue.	Stay - -	Tirant, hauban, support.
Olive joint -	Joint ovale.	Stud - -	
Packing - -	Garniture de presse-étoupe.	Support - -	Support console.
		Union - -	Raccord.
		Washer - -	Rondelle.

The following parts should take the name of the piece to which or in which they are fitted :—

Bearing - -	Coussinet, palier.	Liner - -	Fourrure intérieure.
Bush - -	Bague, douille.		
Housing - -	Emplacement à.	Sleeve - -	Manchon.

English Term.	Definition.	French Equivalent.
Supports for engine.	—	*Supports de moteur.*
Centralising plate	The rearmost support of the crankshaft of a rotary engine.	Plaque centralisatrice.
	Colloquially—	
	Centralising collar - -	Collier centralisateur.
	Back ring - - - -	Collier arrière.
	Rear support - - - -	Support arrière.
	Rear second bearing - -	Second palièr arrière.
Main bearer plate	The principal support at the rear of a rotary engine.	Carlingue principale arrière.
	Colloquially—	
	Back plate - - - -	Plaque arrière.
	Main support - - - -	Support principal.
	Central support - - -	Support central.
Crank case -	—	*Carter.*
Crank Case Sump	—	Carter (à huile).
Reciprocating Parts.	—	*Pieces e mouvement alternatif.*
Master and articulated connecting rods.	An assembly of connecting rods, consisting of a master and one or more rods articulated thereto. The master connecting rod takes the main crank pin pressure.	Bielle maîtresse et bielles articulées.
Connecting rods -	—	Bielles.
Forked connecting rods.	An assembly of connecting rods attached to the same journal in which the big end of one rod is forked to bridge the big end of the other rod. These rods are classified as "forked" and "plain."	Bielles jumelées. Bielles Renault.

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English Term.	Definition.	French equivalent.
Side by side connecting rods.	An assembly of plain connecting rods so arranged that the big ends are side by side on the same crank pin.	Bielles accolées.
Slipper connecting rods.	An assembly of connecting rods having a big end or heel formation, so arranged that several such connecting rods have their big ends operating on one crank pin and held in position by a pair of annular grooved collars, which are colloquially known as thrust blocks.	Bielles glissantes.
Wrist pin	A pin uniting an articulated connecting rod with a master connecting rod. Colloquially—Knuckle pin; big end gudgeon pins	Axe de bielle.
Big end	Crank or wrist pin end of a connecting rod.	Tête de bielle.
Small end	The end of a connecting rod nearer to the piston.	Pied de bielle.
Small end bush	A part in the connecting rod easily replaceable in the event of wear, employed when the gudgeon pin is fixed relatively to the piston (*see* "gudgeon pin bush").	Bague (ou douille) de pied de bielle.
Colloquially	Top bush, Douille supérieure. Connecting rod top bush, Douille supérieure de bielle. Small end bearing, Coussinet de pied de bielle. Piston pin bush, Douille d'axe de piston.	
Piston	—	Piston.
Gudgeon pin	A pin passing through the small end of a connecting rod. Colloquially—Piston, pin, Axe de piston.	Goujon.
Floating gudgeon pin	A pin which is fixed neither to the piston nor the connecting rod, the lateral movement being usually prevented by the use of a circlet.	Goujon flottant.
Gudgeon pin bush	—	Douille de goujon.
Gudgeon pin circlip	A single coil steel wire, which is sprung into a groove in the piston gudgeon pin bosses to prevent endwise movement of the gudgeon pin.	Spirale de serrage de goujon, ou anneau de sureté.
Revolving parts	—	*Pieces a mouvement circulaire.*
Crankshaft	—	Vilebrequin.
Maneton	The small end of the crankshaft of a rotary engine.	Maneton.
Oiling sleeve	—	Manchon de graissage.
Stationary parts fixed parts.	—	*Parties stationnaires parties fixes.*
Cylinders	—	Cylindres.
L-head cylinder	Valves on one side of cylinder	Cylindre en L.
T-head cylinder	Valves on opposite sides of cylinder	Cylindre en T.

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English Term.	Definition.	French Equivalent.
I-head cylinder -	Valves in cylinder head - -	Cylindre en I.
F-head cylinder -	One valve in head; other on side directly operated.	Cylindre en F.
Camshafts, gear.	—	*Arbres a cames, Mecanisme de soupapes.*
Camshaft - -	—	Arbres à cames.
Camshaft timing pinion.	—	Pignon de calage d'arbre à cames.
Camshaft idler pinion.	—	Pignon libre d'arbre à cames.
Camshaft oil pump pinion.	—	Pignon de pompe à l'huile solidaire de l'arbre à cames.
Camshaft ignition distributor pinion.	—	Pignon de distributeur solidaire de l'arbre à cames.
Cam box (on a rotary engine).	—	Boîte à cames (dans le cas d'un moteur rotatif).
Eccentric, inlet or exhaust (on a rotary engine).	—	Eccentrique, d'admission ou d'échappement (dans le cas d'un rotatif).
Exhaust cam -	—	Came d'échappement.
Inlet cam - -	—	Came d'admission.
Valve tappet, inlet or exhaust.	—	Poussoir de soupape, (d'admission ou d'échappement).
Valve tappet guide.		Guide-poussoir de soupape.
Valve tappet guide clamp.	—	Etrier de guide-poussoir de soupape.
Valve tappet roller pin.	—	Axe de galet de poussoir de soupape.
Valve rocker -	(Either at cam or at overhead valve; if both, upper and lower). Colloquially—Exhaust valve lever; valve rocking lever.	Culbuteur de soupape.
Valve rocker bush	—	Coussinet de culbuteur.
Valve rocker fulcrum pin.	—	Axe de culbuteur
Valve rocker bracket.	—	Support de culbuteur.
Valve push rod, inlet or exhaust	(Intermediate between tappet and valve).	Tige de culbuteur.
Valve push rod ball and socket ball joint.	—	Rotule de tige de culbuteur et socquet de rotule de tige de culbuteur
Cap for ball end -	—	Chapeau pour bout à rotule.
Valve push rod eye, the adjusting end of the rod.	—	Bout ajustable de la tige de culbuteur.

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English Term.	Definition.	French Equivalent.
Circlip, a stop ring for preventing endwise movement of the fulcrum pin.	—	Etrier de calage de l'axe de culbuteur.
Valves - -	—	*Soupapes.*
Starting devices, auto starting devices.		*Dispositifs de d'marrage, démarreur automatique*
Hand starter -		Démarreur à main.
Starting handle -	—	Manivelle de mise en marche.
Self-starter - -	—	Démarreur automatique.
Accessory parts of engine.	—	*Parties accessoires du moteur.*
Pipes - - -	—	Tuyaux.
Exhaust pipes -	—	Tuyaux d'échappement.
Exhaust system -	—	Tuyauterie d'échappement.
Exhaust manifold	—	Tuyauterie d'échappement.
Exhaust pipes and silencer.	—	Tuyaux d'échappement et silencieux ou pot d'échappement.
Manometers -	Pressure gauges - - - -	Manomètres.
Floats, petrol level gauges -	—	Flotteurs, indicateurs de niveau d'essence.
Fuel system -	—	*Distribution du carburant.*
Carburettor -	—	Carburateur.
Inlet manifold -	(More than one connection to cylinder).	Tuyauterie d'admission
Inlet pipe - -	(Only one connection to cylinder)	Tuyau d'admission.
Carburettor air heater.	—	Réchauffeur de carburateur.
Carburettor hot air pipe.	—	Tuyau à air chaud du carburateur.
Air intake pipe -	A pipe fitted to the carburettor or induction system through which only air is drawn.	Tuyau d'admission d'air.
Altitude control -	A device fitted to a carburettor or other part of induction system to obtain a correct mixture of the fuel gas at high levels.	Commande altimétrique.
Engine primer or priming device.	—	Amorceur (de moteur).
Fuel tank - -	Colloquially—petrol tank - -	Réservoir à essence.
Fuel reserve tank	—	Réservoir de secours.
Fuel gravity tank	—	Réservoir d'alimentation en charge.
Fuel gauge - -	Colloquially—petrol gauge -	Indicateur de la consommation d'essence.
Fuel tank outlet filter.	—	Filtre de sortie du réservoir d'essence.
Main fuel valve -	—	Soupape du réservoir principal.

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English Term.	Definition.	French Equivalent
Reserve fuel valve	—	Soupape du réservoir de secours.
Fuel pipe, main tank to auxiliary tank.	—	Tuyau d'essence allant du réservoir principal au réservoir auxiliaire.
Fuel pressure pump.	—	Pompe à essence.
Cooling system.		*Systeme de refroidissement.*
Fan	—	Ventilateur.
Radiator	—	Radiateur.
Water pump	—	Pompe à eau
Pipes and fittings	—	Tuyaux et raccords.
Lubrication system.		*Systeme de graissage.*
Oil reservoir	—	Réservoir à huile.
Oil pump	—	Pompe à huile.
Oil pipes, filters, gauges.	—	Guyaux d'huile, filtres, niveaux.
Ignition.		*Allumage.*
Electric ignition system.	—	Allumage électrique
Sparking plugs, wiring and switches.	—	Bougie, fils et commutateurs.
Ignition distributor.	—	Distributeur.
Shrouded distributor.	A distributor with a steel shroud which sometimes embodies a cam for operating a gun gear.	Distributeur à chemise.
Distributors, single or dual.	(*i.e.*, for single or dual ignition)	Distributeur simple ou double.
Magneto	—	Magnéto.
Dynamo	Colloquially—Electric generator	Dynamo.
Ignition control	—	Commande d'allumage.
Magneto lead	(State whether H.T. or L.T.)	Câbles de magnéto.
H.T. cable	—	Câble à H.T.
Connecting lead	—	Fil.
H.T. lead connecting magneto to brush.	—	Fil à haute tension joignant la magnéto au charbon du distributeur.
H.T. lead	—	Fil à H.T.
	METEOROLOGICAL TERMS.	
Altitude	The angle in a vertical plane, subtended at the eye of the observer between an object and the horizon. The word is also used colloquially as synonymous with height.	Altitude.
Azimuth	The angle between the bearing of an object and a line running north and south, *i.e.*, the meridian line.	Azimut.
Sounding	In meteorology the term is used for a trial of heights in the atmosphere with measures of pressure, temperature, humidity or wind velocity.	Sondage.

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English Term.	Definition.	French Equivalent
Mechanics of the atmosphere.		*La mécanique atmosphérique.*
Troposphere	The lower layers of the atmosphere in which the change of temperature with height is relatively large. It is about 17 kilometres thick at the equator and about 10 kilometres thick in northern latitudes.	Troposphère.
Stratosphere	The external layer of the atmosphere above the region of connection, *i.e.*, that in which there is no sensible variation of temperature. The region dividing the troposphere from the stratosphere is generally at a height of about 10 kilometres.	Stratosphère.
General theory of the wind.		*Théorie générale du vent.*
Breeze	A wind of moderate strength	Brise
Gust	Rapid fluctuations in the strength of the wind which are specially characteristic of winds near the surface of the earth	Remous.
Backing	A counter-clockwise change in the direction of the wind. This applies to both Northern and Southern Hemispheres.	Saute de vent à gauche ou rétrogradation du vent.
Line squall	A squall advancing in line over a great extent of country.	Grain.
Cyclones or depressions, tempests.		*Cyclones ou dépressions, Tempêtes.*
Cyclone	The name given to the portion of the atmosphere over a region surrounding a centre of low barometric pressure, now usually spoken of as a depression or a low. *See* "Anticyclone." In a more restricted sense the word is also used for a violent circular storm. *See* "Typhoon," "Hurricane," "Tornado."	Cyclone.
Depression	A region of low barometric pressure surrounded on all sides by higher pressures. *See* "Cyclone."	Dépression.
Typhoon	*See* "Cyclone." In another sense a tropical revolving storm of the China Seas.	Typhon.
Vortex	In meteorology is the central part of a tornado or cyclone.	Vortex.
Storms.		*Orages.*
Whirlwind	A small revolving storm	Tourbillon.
Tornados.		*Tornades.*
Hurricane	"Beaufort Scale." (1) A tropical revolving storm of the West Indies, the equivalent of the typhoon of the China Seas or the cyclone of the Indian Ocean. (2) A wind of force 12 on the Beaufort Scale which is experienced in tropical revolving storms or tornados, but rarely elsewhere.	Ouragan.

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English Term.	Definition.	French Equivalent.
Tornado - -	A short-lived, but very violent, wind, forming part of an intense revolving storm of limited area. *See* "Cyclone," "Vortex," "Whirlwind." In Africa the term is applied to a squall accompanied by a thunderstorm. In America to a whirlwind.	Tornade.
Anticyclone -	The name given to that portion of the atmosphere over a region surrounding a centre of high barometric pressure. *See* "Cyclone."	Anticyclone.
Particular winds of certain regions.		*Vents caractéristiques de certaines régions.*
Trade winds -	Persistent winds blowing from N.E. in the Northern Hemisphere and S.E. in the Southern Hemisphere, between the horse latitudes, about latitude 30° N. or S., and the equatorial doldrums.	Vents alizés.
Horse latitudes -	The belt of calms, light winds and fine clear weather with high barometer met with approximately 30° on either side of the equator. They mark the extreme North and South limits of the trade winds.	Latitudes torrides.
Monsoon -	Winds which blow with great persistence and regularity in opposite directions at different seasons of the year. They are in general confined to tropical regions, and are most marked on the shores of India and China. The term is also applied to the rainy season of India, which sets in with, and is governed by, the monsoon wind which blows from the south-west and west in the summer on the west coast of India.	Mousson.
Land breeze -	An off-shore wind occurring at the margin of a sea or lake during a clear night, due to the more rapid cooling of the air over the land than over the water. During the day the conditions are reversed, and the wind blows from the sea to the land constituting a sea breeze.	Vent terrestre.
Lake breeze -	A breeze blowing on to the coast of a lake in sunny weather during the middle of the day, part of the convectional circulation induced by the greater heating of the land than of the water.	Vent venant d'un lac.
Chinook - -	The wind of the western prairies of America which comes down from the Rocky Mountains as a warm, dry, west wind.	Chinook.

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English Term.	Definition.	French equivalent.
Valley breeze -	A day breeze that blows up valleys when the sun warms the ground.	Vent de vallée.
Foehn - -	The dry, warm wind of the valleys on the northern side of the Alps.	Foehn.
Mistral - -	A strong, dry wind experienced on the Mediterranean coast of France. It blows from the N.W.	Mistral.
Bora - - -	A very violent, squally, cold wind occurring in the Northern Adriatic, blowing from N.E.	Bora.
Northern blizzard	A gale of wind with the temperature below freezing, the air being filled with fine, dry snow.	Tempête de neige
Sirocco - -	The hot, damp, southerly wind of Southern Italy, prevailing on the S.E. side of a depression traversing the Mediterranean from west to east. The term is also applied to the hot, dry, southerly wind prevailing under similar meteorological conditions on the Algerian coast. These hot, dry, southerly winds are known also by the following local names: Samum in Algeria; Chili in Tunis; Gibli in Tripoli; Khamsin in Egypt.	Siroco.
Harmattan -	A very dry N.E. wind which is prevalent in Western Africa during the dry season (November to March).	Harmattan.
Glacial breeze -	A cold breeze blowing down the course of a glacier, and owing its origin to the cooling of the air in contact with the ice.	Vent glacial.
The doldrums -	The equatorial belt of low pressure. It is a region of calms and light variable airs, associated with heavy rains, thunderstorms and squalls.	Les dolrurms.
Dew, hoar frost, rime.		*Rosée, Gelée blanche, givre.*
Dew point - -	The temperature of the air below which moisture in the air condenses in the form of dew or fog.	Point de rosée.
Rime - - -	Ice crystals, like small needles, which form on trees and buildings in foggy, frosty weather.	Givre.
Fog.		*Brouillard.*
Fog - - -	Opacity of the atmosphere, sufficient to impede navigation or locomotion. It is usually caused by particles of moisture.	Brouillard.
Haze - - -	An obscurity of the atmosphere occurring in dry weather. It may be due to particles of dust or smoke or irregularities of the density of the air reducing visibility.	Brûme.

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English Term.	Definition.		French Equivalent.
Mist	Cloud at the level of the ground, consisting of minute drops of water suspended in the air.		Bruine.
Clouds. Cloud Sheets:			*Nuages.* Ciel nuageux :
Cirrus	Mares' tails; wisps or lines of pure white clouds with no shadows.	Upper cloud layer about 30,000 ft.; clouds composed of ice crystals. With these are sometimes seen halos or rings at some distance from the sun and moon.	Cirrus.
Cirro-cumulus	Small speckles and flocks of white clouds; fine ripple clouds; mackerel sky.		Cirro-cumulus.
Cirro-stratus	A thin sheet of tangled web structure, sometimes covering the whole sky; watery sun or moon.		Cirro-stratus.
Cirro-nebula	Similar to the last, but a veil of cloud with no visible structure.		Cirro-nebula.
Alto-cumulus	Somewhat similar to cirro-cumulus, but the cloud masses are larger and show some shadow.	Middle cloud layer, 10,000 ft. to 25,000 ft. Clouds composed of minute drops of water. Coloured rings, sometimes seen quite close to sun and moon, but never halos.	Alto-cumulus.
Alto-cumulus castellatus	Turret cloud; alto-cumulus with upper margins of the cloud masses developed upwards into miniature cumulus with hard upper edges. (Sign of thunder.)		Alto-cumulus Castellatus.
Alto-stratus	Very like cirro-stratus and cirro-nebula but a thicker and darker cloud.		Alto-stratus.
Strato-cumulus	Cloud masses with some vertical structure; rolls or waves sometimes covering the whole sky.		Stratus-cumulus.
Stratus	A uniform layer of cloud resembling fog but not resting on the ground.		Stratus.
Nimbus	Shapeless cloud without structure from which falls continuous rain or snow.	Lower cloud layer. Below 7,000 feet.	Nimbus.

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English Term.	Definition.	French Equivalent.
Scud (fracto-nimbus).	Small, shapeless clouds with ragged edges; sometimes seen without other cloud, especially in hilly country; but more commonly seen below other clouds, such as cumulus and nimbus.	Fracto-nimbus.
Heap clouds -	The height of the heap clouds is very variable. Mean height of base about 4,500 feet; the height of the top varies from about 6,000 to 25,000 feet.	Nuages tassés.
Cumulus - -	Woolpack clouds; clouds with flat base and considerable vertical height. Cauliflower-shaped top.	Cumulus.
Fracto-cumulus -	Small cumulus with ragged tops	Fracto-cumulus.
Cumulo-nimbus -	Anvil cloud thunder cloud or shower cloud. Towering cumulus with the top brushed out in soft wisps or larger masses of fibrous cloud which are called false cirrus and the base is a rain cloud.	Cumulo-nimbus.
Rain snow.		*Pluie neige.*
Rainfall - -	The depth of water which falls on a given area from the atmosphere. The term is often taken to include rain, snow, hail, sleet, etc., *i.e.*, the total water collected in the rain gauge. Precipitation is the proper inclusive term.	Hauteur de pluie.
Optical phenomena.		*Phénoménes optiques.*
Mirage - -	The phenomenon in which an image is seen displaced, upwards or downwards, usually vertically, by the refraction of the rays of light in their passage through layers of air of different densities near the ground.	Mirage.

TIMBER NAMES

English Name.	French Name.	Native Country.
Oak.	*Chêne.*	
British oak - -	Chêne pedonculé -	Europe, including the British Isles; Caucasus; Asia Minor.
French oak - -		
Austrian oak - -	Chêne rouvre -	—
Russian oak - -		
American white oak	Chêne blanc américain.	Eastern North America.
American red oak -	Chêne rouge américain.	Eastern North America.
Ash.	*Frêne.*	
European - -	Frêne commun -	Europe, including the British Isles; Caucasus; Asia Minor.

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English Term.	French Name.	Native Country.
Ash.	*Frêne.*	
American white -	Frêne blanc américain.	Eastern North America.
Maple.	*Erable.*	
English maple -	Erable champêtre	Europe, including the British Isles; Western Asia; Algeria.
American maples -	Erables américains	—
Sycamore - -	Erable sycomore -	Europe, including the British Isles; Western Asia.
Elm.	*Orme.*	
English elm - -	Orme champêtre -	Southern England and possibly Spain.
Wych elm - -	Orme de montagne	Europe, including the British Isles; Caucasus; Asia Minor; N.E. Asia.
Rock elm, U.S.A. -	Orme à grappe -	Eastern North America.
Birch.	*Bouleau.*	
American birch -	Bouleau américain	—
Lime.	*Tilleul.*	
European lime -	Tilleul intermédiaire.	Europe.
American lime -	Tilleul d'Amérique	Eastern and Central North America.
Poplar.	*Peuplier.*	
White poplar, Europe.	Peuplier blanc ou peuplier de Hollande - -	Europe; North Africa; North and West Asia.
Grey poplar, England.	Peuplier gris, peuplier grisaille, peuplier grisard.	Western Europe, including the British Isles.
Black poplar, England.	Peuplier noir -	Europe, including the British Isles; Morocco.
Black Italian poplar England.	Peuplier suisse -	—
Black cottonwood, British Columbia.	Peuplier du Canada.	Western North America.
American balsam -	Peuplier baumier, ou peuplier de Gilead.	North America.
Cottonwood - -	Bois de peuplier -	North America.
Willow.	*Saule.*	
Bat willow - -	Saule blanc - -	Eastern Counties of England.
Fir.	*Sapin.*	
Silver fir, Europe -	Sapin pectiné -	Mts. of Central and Southern Europe.
Balsam fir, U.S.A.; Canada.	Sapin baumier -	North America from Labrador to the Northern U.S.A. and Virginia.
Oregon white fir -	Sapin noble - -	Western U.S.A. from Washington to Northern California.
Californian white fir	Sapin blanc de California.	Western and South Western U.S.A. and Northern Mexico.
Japanese fir, N. Japan, N.E. Siberia.	Sapin japonais -	Saghalien; Kurile Islands; North Japan.
Douglas fir - -	Sapin de Douglas-	Western North America and Northern Mexico.
Spruce.	*Epicéa.*	
European spruce -	Epicéa - -	Europe.
White spruce - -	Epicéa blanc -	Eastern Canada and North Eastern U.S.A.

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English Term.	French Name.	Native Country.
Spruce	*Epicéa.*	
Black spruce	Epinette noir	North America from Alaska to Labrador and southwards from the North Eastern U.S.A. to South Virginia.
Sitka spruce	Epicéa de Sitka	Western North America from Alaska to California.
Japanese spruce	Epicéa japonais	Japan.
Larch.	*Mélèze.*	
European larch	Mélèze	Mountains of Central and Southern Europe.
Northern larch, N. Russia.	Mélèze de Sibérie	North Eastern Russia and Siberia.
Western larch, Rocky Mountains.	Mélèze occidental	British Columbia and North Western U.S.A.
Cedar.	*Cedre.*	
Lebanon Cedar	Cèdre du Liban	Mountains of Syria, Asia Minor.
Algerian cedar	Cèdre d'Algérie	Algeria and Morocco.
Deodar	Cèdre Déodar	Himalaya and Afghanistan.
Pine.	*Pin.*	
Scotch pine	Pin sylvestre	Nearly the whole of Europe, including Scotland; Northern and Western Asia.
Siberian pine	Pin cembro	Alps; Carpathians; North East Russia; Western Siberia.
White pine	Pin de Weymouth	Canada; Northern and Eastern U.S.A.
Western white pine	Pin de montagne, pin à crochet.	British Columbia and Western U.S.A. from Washington and Montana to Central California.
Canadian red pine	Pin rouge	Canada and Northern U.S.A.
Bull pine	Pin-jaune de Californie.	Western North America from British Columbia to Lower California and Northern Mexico.
Loblolly pine	—	South Eastern U.S.A.
Hard pine	Pin de goudron	Eastern North America.
Short-leaf pine	Pin court-feuille	Eastern U.S.A.
Pitch pine	Pitch pin	South Eastern U.S.A.
Manchurian pine	Pin de Mandchourie.	Eastern Siberia; Manchuria; Korea; Japan.
American Sweet Gum	*Copalm.*	Eastern U.S.A.; Mountains of Mexico and Guatemala.
Cypress.	*Cyprès.*	
Louisiana Cypress	Cyprès	Southern U.S.A.
White Cypress, Eastern U.S.A.	Cèdre blanc	Eastern U.S.A.
Yellow cypress, British Columbia, Alaska.	Cèdre jaune	Western North America from Alaska to Washington and Oregon.
Port Orford cedar, Oregon.	Cyprès de Lawson	South West Oregon to Northern California.
Giant Thuya, Western U.S.A.	Thuya gigantesque	Western North America from Alaska to Central California.
Hemlock.	*Cigue.*	
Canada Hemlock	Peruche	Canada and Eastern U.S.A.
Western Hemlock	Peruche occidentale.	Western North America from Alaska to California.
Sequoia.		
U.S.A. and England	Rouge-bois	California.

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English Name.	French Name.	Native Country.
Mahogany.	*Acajou.*	
Honduras - -	Acajou d'Honduras.	—
Nicaraguan - -	Acajou du Nicaragua.	—
Mexican - -	Acajou du Mexique	—
Guatemala - -	Acajou du Guatemala.	—
Panama - -	Acajou du Panama	—
Columbian - -	Acajou du Colombie.	—
West African - -	Acajou d'Afrique	—
Butternut.		
U.S.A. - - -	Noyer cendré -	Canada and Eastern U.S.A.
Walnut	*Noyer.*	
European walnut -	Noyer - - -	South Eastern Europe to the Himalayas; North China and Japan.
Black walnut, U.S.A.	Noyer noir - -	Southern Canada and Eastern U.S.A.
Japanese walnut, Kurumi.	Noyer japonais -	Japan.
Magnolia.	—	Eastern U.S.A.
Tulip Tree.	*Tulipier.*	
U.S.A. - - -	Tulipier - -	Eastern North America.
Hickory - -	*Hickory* - -	Eastern North America.

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